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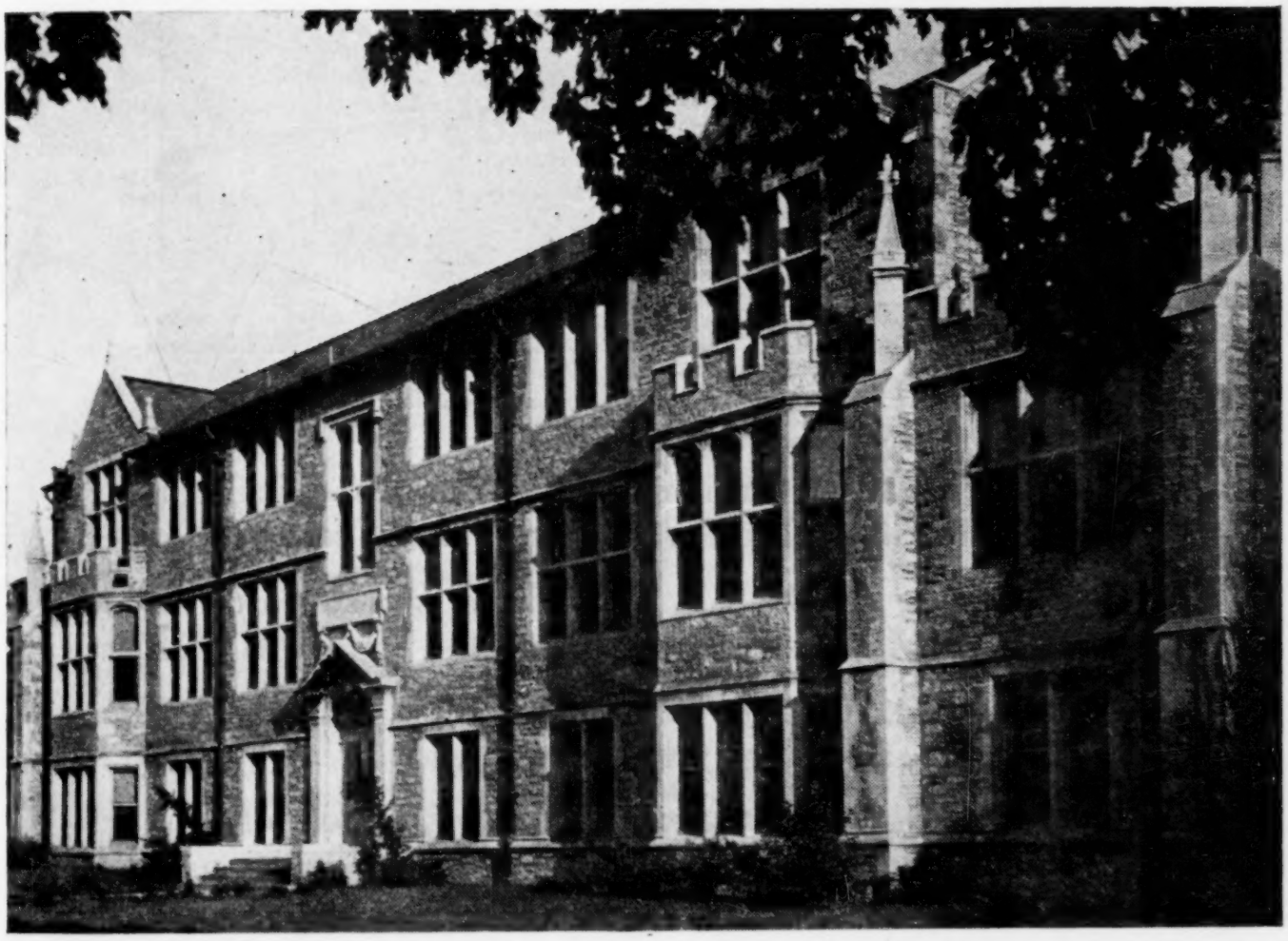

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World Soil and Fertilizer Resources

Robert M. Salter

For the Physiological Laboratory

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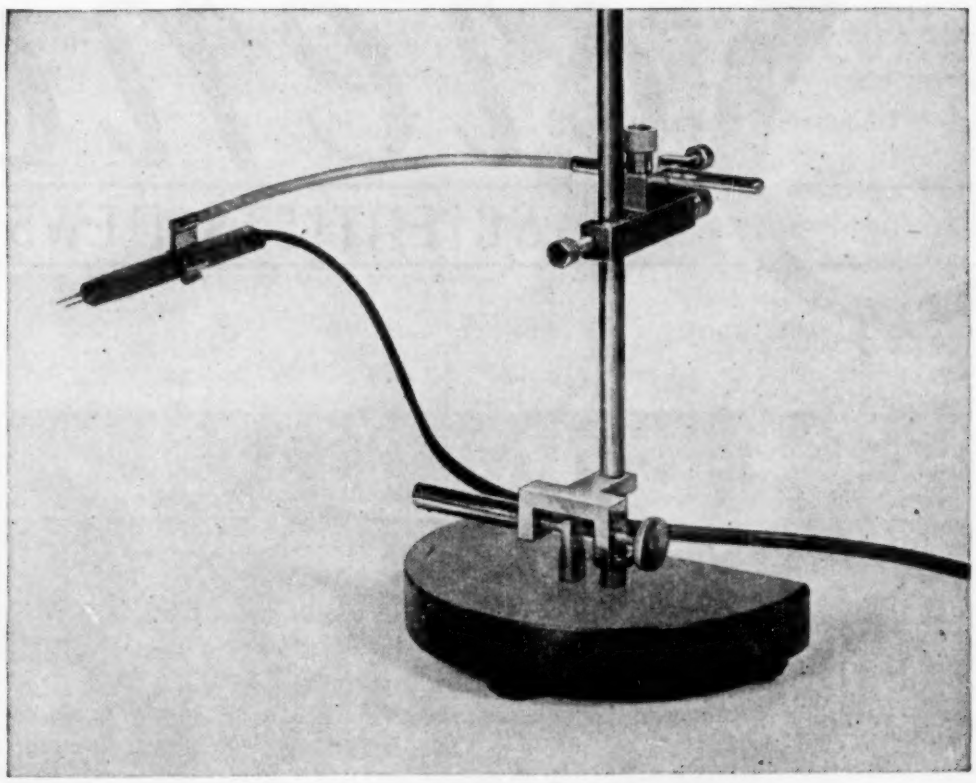

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Science

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World Soil and Fertilizer Resources in Relation to Food Needs

Robert M. Salter, *Chief,*

Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture, Beltsville, Maryland

HUNGER AND STARVATION HAVE stalked the footsteps of man since the dawn of history. Only with the bloom of modern science in the last half century has there for the first time come hope that these gaunt specters could be banished if man but willed it so. Through the centuries those in positions of leadership have been prone to accept the misery of hunger as an unavoidable fact of life, the result of population pressure on a limited food supply.

In the midst of the most destructive war in history the leaders of the Allied Nations determined that one of the goals of victory should be *freedom from want*. To some, science appears to offer a basis of fact for this ideal. Here in our own country, farmers applied the results of agricultural research so efficiently during the war years that, despite many difficulties, production of food crops reached and held an unprecedented peak. It seems reasonable that, with the peace, benefits of agricultural research may be extended still further and that all the people of the world may be better fed.

The high ideals that came with the fervor of the war are now being evaluated coolly in the light of peacetime realities. The peoples of the warring nations are determined to be practical. With skeptical minds they are asking: Is it, after all, reasonable to hope that the world can produce enough to feed all its human inhabitants? Can the world's soil grow all the crops that would be needed? Are fertilizer sources great enough? Do we have the technology and management ability to produce the crops and maintain the soils? These questions do not encompass the whole problem by any means, but these are questions I am being asked. I am glad to try to answer them, for I am convinced that we do have the soils we need, we do have the fertilizer resources, we have available the management ability, and we could produce enough food for all.

But how much is enough? We have an answer suitable for our purpose from the recent "World Food Survey" made by the Food and Agriculture Organization of the United Nations. By 1960, if everyone is to have an adequate diet, the world will need, according to the estimates of this survey, the following increases beyond prewar production: cereals, 21 per cent; roots and tubers, 27; sugar, 12; fats and oils, 34; pulses and nuts, 80; fruits and vegetables, 163; meat, 46; and milk, 100.

Considering only the natural physical resources needed to obtain these increases in food production, and with acute awareness of many other problems involved, there are two obvious courses we can follow in seeking higher food production the world over. First, and perhaps as the easier course, we could obtain much of the increase through more intensive and more efficient use of the land now farmed. Second, with our knowledge of world soil types, we could expand production in the areas having undeveloped soil resources.

Some of the possibilities of intensive and efficient production are readily evident in our own war experiences. Production of food crops was maintained at about 35 per cent above the period 1935–39. Admittedly, weather was more favorable than during the prewar years, but even with no more favorable weather the production would have been 20 per cent greater, despite the fact that the labor force was actually 6 per cent smaller.

Our experiment stations and our more successful farmers provide many illustrations of the opportunity for increasing food crop yields and animal production by applying these improved agricultural techniques more widely. Thus, the limiting factors to increased production seem to be lack of education and lack of capital rather than any limits of physical production capacity. For example, recent experiments on corn culture in the Southeast under ordinary farm conditions show that corn yields for that area can be more than doubled by a combination of improved practices. In addition to regular fertilization practices, these include heavy nitrogen treatment combined with the growing of adapted hybrids, closer spacing to take advantage of heavier fertilization, and early and shallow cultivation for weed control. By 1960 perhaps, 50-bushel-per-acre corn production in the Southeast will be the rule rather than, as today, the exception.

This and many other examples would indicate also that the estimates of production possibilities after the war, under prosperity conditions, made cooperatively by the U. S. Department of Agriculture and the land-

The information contained in this paper was presented as a part of a panel before Section O (Agriculture) at the annual meeting of the AAAS, Boston, December 30, 1946.

grant colleges, are really conservative, though they may appear somewhat optimistic. According to these estimates, by 1950 appreciable increases in production per acre of most of our principal crops over that obtained in the 1935–39 period can be readily attained. The estimated increases were as follows: corn, 31 per cent; hay, 28; wheat, 18; rice, 13; peanuts, 20; sugar beets 17; potatoes, 22; and sweet potatoes, 31.

TABLE 1

ESTIMATED ATTAINABLE INCREASE IN YIELD DUE TO IMPROVED PRACTICES

Crop		Yield	
		1935–39	1960
USSR			
Wheat	bushels	10.0	12.0
Rye	"	12.7	13.5
Corn	"	16.3	20.0
Oats	"	22.2	28.0
Barley	"	14.9	18.0
Sugar beets	tons	6.1	8.0
Potatoes	bushels	121.5	180.0
India			
Wheat	bushels	10.7	20.0
Rice	"	26.2	40.0
Corn	"	12.9	20.0
Barley	"	16.5	20.0
Peanuts	pounds	400.0	600.0
China			
Wheat	bushels	14.9	18.0
Rice	"	52.5	70.0
Corn	"	24.2	35.0
Barley	"	21.8	24.0
Peanuts	pounds	769.0	1,000.0
Soybeans	bushels	16.8	20.0
Dry beans	pounds	730.0	1,000.0
Potatoes	bushels	100.0	150.0
United States			
Corn	bushels	28.1	36.7
Oats	"	31.7	38.5
Hay	tons	1.4	1.8
Potatoes	bushels	124.0	152.0
Soybeans	"	18.5	21.9
Peanuts	pounds	765.0	916.0
Wheat	bushels	12.4	14.6
Rice	"	47.5	53.6

The United States, which alone cannot feed the hungry of the world, must look to other countries also to intensify food production, preferably in the food-deficient areas. Prior to the war, Europe, with the exception of Poland, Russia, and the Balkans, had reached a high degree of intensified farming in relation to its soil resources. Significant increases in the more highly developed European countries are thus doubtful. If, however, we take into account yield increases readily attainable in different soil regions of the United States, we can safely predict those in other countries possessing the same great soil groups. Such predictions for China, India, and the Soviet Union, the world's three most populous countries, are given in Table 1. These take into account the present reported average yields and the general intensity of present cropping practices, in so far as they are known. Yield increases considered attainable in these countries by 1960 are substantially equivalent to those considered attainable in the United States by 1950, as reported in *Peace-time adjustments in farming*, (U. S. Department of Agriculture, Miscellaneous Publ. No. 593).

It is impossible with the data available to make predictions on possible production in increases by individual crops the world over, because acreage, yield, and production of many important crops are not reported by all countries. Also, much of the world's food supply comes from animal products, and the efficiency of this production in different countries is not known. But we can estimate probable increases in world production of the principal 8 classes of food, by applying to each class the percentage increases of about the same magnitude as those thought attainable by 1950 for the principal crops in the United States. Table 2 is an estimation of the world food supply possible in 1960 as a result of more intensive and better farming methods on present cropland compared with the supply needed in 1960 to give all the people of the world an adequate diet, as estimated in the FAO survey.

TABLE 2

PREWAR FOOD PRODUCTION AND PERCENTAGE INCREASES ATTAINABLE FROM MORE INTENSIVE USE OF PRESENT CROPLAND*

	Cereals	Roots and tubers†	Sugar	Fats and oils	Pulses and nuts	Fruits and vegetables‡	Meat	Milk
Prewar production (millions of metric tons)	300.4	153.2	30.0	15.2	36.2	156.3	65.6	150.2
Increase attainable from present cropland (%)	20	50	15	20	20	35	20	20
Attainable production from present cropland (millions of tons)	360.0	230.0	34.5	18.0	43.4	211.0	78.7	180.2
World food needs in 1960 (millions of tons)	363.5	194.5	33.6	20.4	65.2	411.0	95.8	300.0

* For 70 countries including 90 per cent of world population.
† Including bananas.
‡ Including eggs and fish.

In arriving at these estimates it is necessary to assume that the total prewar world food supply equaled prewar food consumption. The figures for prewar world food supplies were therefore obtained by multiplying per capita consumption, as reported in the FAO survey, by

world population. Larger percentage increases were applied to roots and tubers and to fruits and vegetables because of the apparent opportunity for greatly increasing yields of these crops by the generous use of fertilizers.

On the basis of these estimates, world food needs in 1960 could be met for sugar and for roots and tubers on existing cropland, the need for cereals could virtually be met, but production of all other classes of food would fall short of the need.

It should be borne in mind, however, that the increases assumed to be attainable on existing cropland are conservative. There seems little doubt that a general use of high rates of fertilization on soils that will respond, coupled with modern techniques of insect and disease control, a change in land use patterns, selection of the best varieties, flood and erosion control, and adoption of other lesser techniques, would result in even larger increases.

There are even greater opportunities, but more difficulties perhaps, in increasing food production by bringing new lands into cultivation. At present only 7–10 per cent of the total world land area is cultivated. Except for some desert areas, perpetual snow and ice, tundra, and the most rugged mountains, there is virtually no limit to the acreage that can be brought into cultivation, save the economic limits of costs and returns. When we consider the great soil groups of the world and the relatively small extent to which some of them are already in cultivation, these possibilities become more apparent.

Soil maps have been made of many parts of the world. During the past few years our Bureau has made serious attempts to assemble these into a series of maps of uniform nomenclature, so that various regions can be compared, and to fill in unmapped areas through careful study of climatic, geological, and other relevant data. Although this research is uncompleted, it has given soil scientists an opportunity to arrive at a few general preliminary judgments about our soil resources. A very small-scale, exceedingly generalized map of the world compiled some time ago may be useful to indicate the location of the food soil area of the world (Fig. 1).

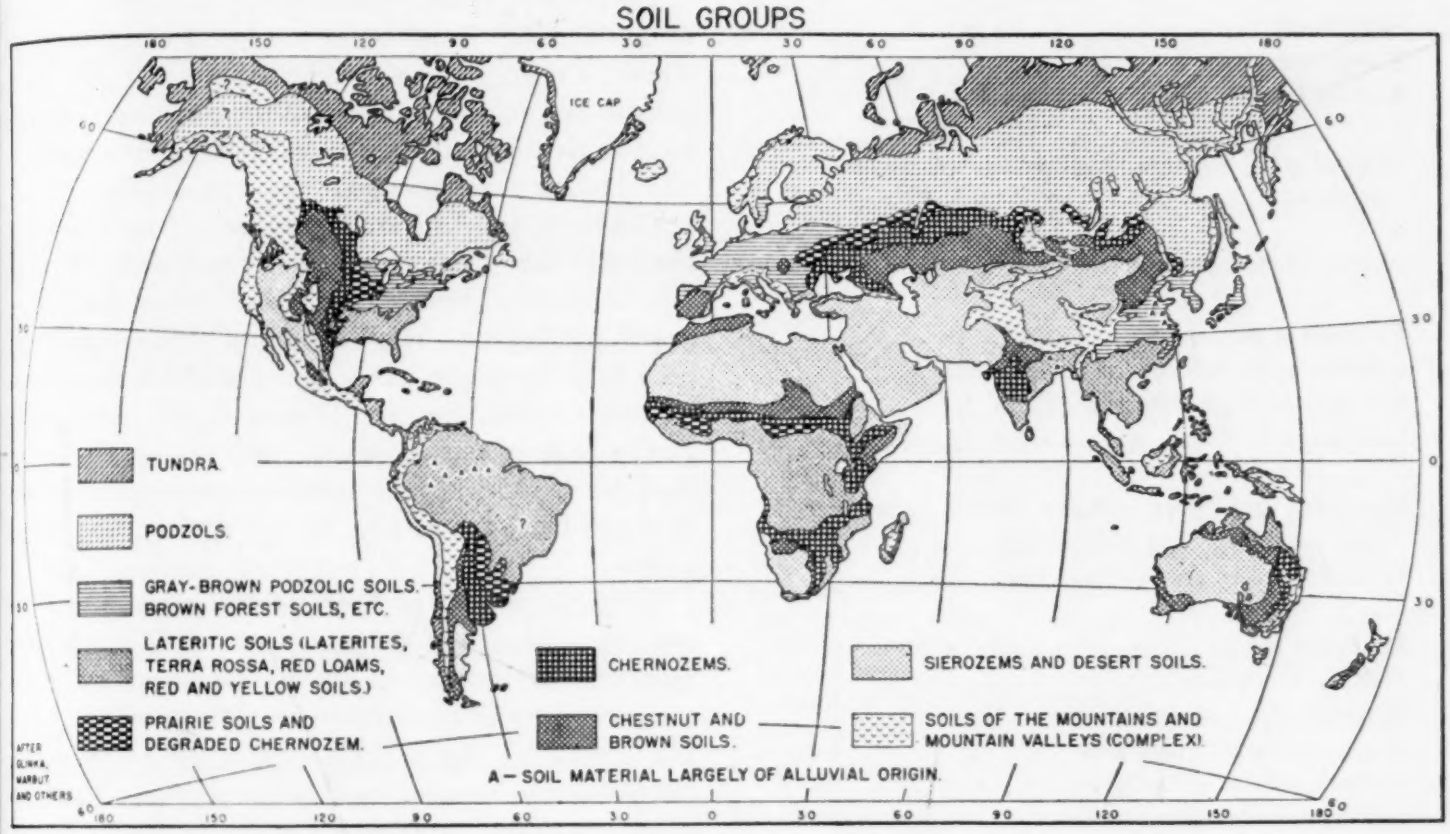

FIG. 1. Schematic map of important soil groups.

Snow and ice, tundra, mountains, and deserts total 48 per cent of the world land areas. We can assume that these areas have no practical possibilities for extension of agriculture. The chernozem, chestnut, gray forest, podzol (including gray-brown podzolic), the red soils of the tropics and subtropics, and alluvial soils occupy an estimated 52 per cent. In this 52 per cent we can look for areas for expansion of agriculture. The chernozem and chestnut soils are now largely under cultivation, and no great expansion into new areas can be foreseen. Some reclamation of alluvial soils, either by drainage or irrigation, or both, should be possible in the tropics.

Prassolov (*Pedology*, 1946, No. 2) estimates the areas of the world in 10 broad classes of soils, as follows:

	Per cent
Chernozems	6
Chernozem soils of prairies	
Black soils ot tropical regions	
Chestnut soils of dry steppes, (including Solonetz)	7
Gray forest	7
Brown forest	
Slightly leached soils of dry forests	
Alluvial soils, marshes, and swamps of tropical regions	4
Podzols (including bogs)	9
Red soils of subtropics	19
Reddish-brown soils of tropical savannas	
Red soils of tropical forests	
Lateritic soils	
Sierozems and other soils of desert steppes and oases (including Solonchaks)	17
Sands and stony soils of the deserts	
Mountain tundra	16
Mountain meadows	
Mountain-forest podzols	
Mountain-forest brown soils	
Mountain-forest red soils	
Soils of mountain steppes	
High mountain deserts	
Tundra	4
Everlasting snow and ice	11

The podzols of the North Temperate Zone and the red soils of the tropics and subtropics constitute the extensive soils onto which great expansion of food production might be possible. Although these occupy an estimated 28 per cent of the world land area, probably less than 1 per cent is now under cultivation. It is recognized, of course, that a large proportion of these soils are unsuitable for agriculture because of the unfavorable topography and stoniness.

The principal areas of red soils are in Africa, South America, southeastern Asia, including India, the Pacific Islands, and southeastern North America. Most areas of red soils are now in use in southeastern Asia and India, and large areas are in use in some of the Pacific Islands and in the United States; but their resources are almost untouched in Africa and South America. If we assume that only 20 per cent of the red soils of the tropics in South America and Africa alone were to be brought into production, about 900,000,000 acres would be added for food production. To these potential cultivated new areas of red soils may be added a large area of uncultivated tropical soils found on the great islands of Sumatra, Borneo, New Guinea, and Madagascar. Assuming, then, that at least another 100,000,000 acres of red tropical and alluvial soils are available in these and other warm parts of the world, the total of 1,000,000,000 acres of tropical and subtropical soils may be used in calculating world soil potentialities.

The podzols, located almost wholly in the northern part of the Northern Hemisphere, are found mostly in Soviet Russia, Canada, and the United States. If we were to assume that only 10 per cent of these soils were brought into cultivation, another 300,000,000 acres would be added to the world acreage for food production.

The world's uncultivated areas are, of course, generally less fertile than those already under cultivation. To maintain continued productivity, these would need fairly heavy fertilization. The question of serious erosion, especially in the tropical areas, must be met if there is to be expansion in this direction. In the last two decades, however, a body of science dealing with erosion control has been developed, which gives us confidence that the problem can be met adequately. We can develop; we need not exploit.

If this huge body of 1,300,000,000 acres of new land were brought into production, what would be the world food picture? Here again, we must estimate by making comparisons with production figures from similar areas. For estimating the possible production of the 1,000,000,000 acres of tropical land, we have chosen the Philippines as a yardstick because it is one of the few tropical countries that can be considered fairly representative of the tropical soil region and that had even approximately complete food-production records. Finland was chosen similarly as representative of the 300,000,000 acres available in the podzol group. By applying the approximate production per acre of the principal classes of food obtained in the Philippines to the above acreage of tropical soils and that obtained in Finland to the acreage of podzol soils, we arrive at the data presented in Table 3.

World food needs in 1960 could thus be met for all classes of food except meat, milk, and pulses and nuts, by production increases on present cropland acreage plus the production of 1,000,000,000 acres of tropical soils, if these soils were used as intensively and for the same classes of food products as are the cultivated soils of the Philippines. We could have more than enough cereals, roots and tubers, sugar, fats and oils, and fruits and vegetables. In addition, the need for pulses and nuts could be easily met or exceeded by shifting some of the production of coconuts from oil to edible nuts.

If production of 300,000,000 acres of North Temperate Zone soils were added to the increase from the present cropland and used as intensively and for the same classes of food products as are the cultivated soils of Finland, the

world food needs in 1960 would be met for cereals, roots and tubers, sugar, and milk, and, in addition, the need for fats and oils would be very nearly met.

World production from all our three sources combined —present world cropland, 1,000,000,000 acres of new tropical, and 300,000,000 acres of extratropical soils—would exceed world food needs for all classes of food except pulses and nuts, under the assumption used, and would exceed them for all classes if part of the production of coconuts were shifted from coconut oil to edible nuts. Production of cereals, roots and tubers, sugar, and fats and oils would be far in excess of what is needed.

TABLE 3

POTENTIAL FOOD PRODUCTION IN MILLIONS OF METRIC TONS FROM MORE INTENSIVE USE OF EXISTING CROPLAND PLUS DEVELOPMENT OF ADDITIONAL LAND NOT NOW CULTIVATED

	Cereals	Roots and tubers	Sugar	Fats and oils	Pulses and nuts	Fruits and vegetables	Meat	Milk
Attainable production from present cropland	360.0	230.0	34.5	18.0	43.4	211.0	78.7	180.2
Attainable production from present cropland plus 1,000,000,000 new acres tropical soils*	717.5	469.5	177.5	69.5	55.4	470.0	89.4	188.8
Attainable production from present cropland plus 300,000,000 new acres land outside tropics†	395.5	296.0	35.1	19.4	44.2	211.0	86.1	314.6
Attainable production from all above sources	753.0	535.5	178.1	70.9	56.2	470.0	96.8	323.2
World food needs in 1960	363.5	194.5	33.6	20.4	65.2	411.0	95.8	300.0

*Obtained by applying approximate average production per crop acre in the Philippine Islands to 1,000,000,000 acres.

†Obtained by applying approximate average production per crop acre in Finland to 300,000,000 acres of Northern Hemisphere soils. Fats and oils and fruits and vegetables are *underestimated* because Finnish production figures on farm-made butter, meat, fruits, and vegetables were unavailable.

To meet world food needs, then, much less than all of these sources of production could be required if efforts were made to produce primarily those classes of foods in deficit.

In discussing potential world food production, either through intensified farming of old land or by developing new areas, there is one overlying factor affecting both. Greatly increased quantities of fertilizer will be required. How adequate are world supplies of fertilizers?

Since nitrogen fertilizer can be manufactured by fixation of nitrogen from the atmosphere, world supplies are limited only by the capacity of plants to produce. This plant capacity was expanded greatly in the last decade because nitrates are a necessity of war.

With phosphate and potash, on the other hand, we must depend on natural deposits to fill world needs. Table 4 compares probable phosphate and potash supplies with potential needs for meeting world food goals. Again it is necessary to make several assumptions. First, we assume that present world cropland would scarcely need a heavier rate of application than is now used in France. It will be noted that the rate of fertilization in France is several times the present world rate. Second, we assume that the additional 1,000,000,000 acres of tropical soils would scarcely need heavier applications than the rate in Hawaii, which is among the highest for all tropical areas. Third, we assume that the 300,000,000 acres of extratropical soils will again need no heavier rate of application than that of France. Thus, in all three areas for comparative purposes we have chosen countries that use fertilizer at a relatively high rate, so that the estimate on world reserves would be conservative.

TABLE 4

FERTILIZER IN RELATION TO EXPANDED FOOD PRODUCTION*

Rate of fertilizer use in kg./hectare of land used for crops:

	P_2O_5	K_2O
World	5.0	3.2
United States	4.9	2.6
France	17.1	12.7
Hawaii	41.0	80.0

World annual requirement of fertilizer under expanded food production:

	P_2O_5 (metric tons)	K_2O (metric tons)
On 1,940,000,000 acres existing cropland at rate of France	13,425,000	9,970,000
On 1,000,000,000 acres (new) tropical soils at rate of Hawaii	16,400,000	32,000,000
On 300,000,000 new acres extratropical soils at rate of France	2,000,000	1,500,000
Total	31,825,000	43,470,000
	P_2O_5 (billion metric tons)	K_2O (billion metric tons)
Probable world reserves	66	22.5
	(years)	(years)
Years supply will last under expanded food production	2,000	500

*Data on fertilizer use from USDA Misc. Publ. 593.

The resulting quantities of fertilizer used under these conditions would be about 8 times the present consumption of phosphate and nearly 18 times the present consumption of potash. Even so, the known world reserves of phosphate would last more than 2,000 years and the known reserves of potash 500 years. The world has not been thoroughly explored for these minerals. Doubtless the actual reserves greatly exceed the known reserves.

There are also many sources of potash other than those included in the probable reserves that may be developed when economical methods of extraction are devised. This latter point again emphasizes how conservative these estimates are, for no allowance was made for technical improvements, which are sure to come in the fertilizer industry.

Here, then, is an affirmative answer to the question: Do we have the natural resources to meet world food goals by 1960? This answer is a challenge to all men, not to scientists only, for it raises immediately an even more critical question: Can we mobilize these resources to produce the needed food? This question begs many answers, because it involves the whole field of human relationships.

Science may discover and point the way, but it cannot dictate. The full measure of success in economic, social, and political action comes only with the will of the majority—not from the desires of one group.

If the people of the world really have the determination to give battle to the problem of hunger, if they are willing to extend a small part of the energy and capital poured into World War II, only then can we see hope of victory.

Modern Concepts of Inflammation

Valy Menkin

Department of Surgical Research and Agnes Barr Chase Foundation for Surgical Research, Temple University School of Medicine, Philadelphia

INFLAMMATION IS THE PHYSICAL BASIS OF infectious diseases, although inflammation and infection should not be considered as synonymous terms. Inflammation implies a more inclusive concept. It is a manifestation of severe cellular injury in higher forms. As such, the inflammatory reaction requires the presence of vascular and lymphatic structures as well as tissue cells. The reaction, which is initiated by a disturbance in fluid exchange, manifested primarily by an increase in capillary permeability, tends to be stereopatterned. It can be modified by the nature of the irritant, which, per se, has its specific chemical affinity with the tissues of the host. Furthermore, the topographical location of the injury doubtless alters the ultimate picture of the lesion. Nevertheless, close scrutiny reveals throughout a fundamental pattern which is largely referable to various basic common denominators or biochemical units liberated by injured cells, irrespective of the nature of the stimulating irritant. It therefore behooves us to concentrate on a study of the biochemistry of injured cells.

The initial increased capillary permeability and the early migration of polymorphonuclear cells is primarily caused by a polypeptide to which there may be attached a prosthetic group. This substance, called *leucotaxine*, was identified in exudative material some 10 years ago. It is not possible here to go into the details employed in its isolation and properties. Suffice it to say that leucotaxine has no similarity to histamine and, as such, has no relation to the so-called hypothetical H-substance of the late Sir Thomas Lewis. It evidently is wholly different from hyaluronidase, acetylcholine, or adenine compounds. Cullumbine and Rydon in Great Britain have recently confirmed by a somewhat different procedure of extraction its presence in exudates and also its properties (*Brit. J. exp. Path.*, 1946, **27**, 33).

Leucotaxine fails to alter the number of circulating leucocytes when administered intravenously. It appears as if the state of leucocytosis accompanying a number of inflammatory processes is caused by a wholly different basic factor or common denominator. When exudative material, particularly, though not always, at an alkaline pH, is injected into the blood stream of a normal dog, a rise in the number of circulating leucocytes occurs. This rise may take place in an hour in some animals, whereas in others it may be significant in only three to four hours. Thus, a leucocytosis-promoting factor is liberated by injured cells, which can in turn be recovered from exudates. Neither normal blood serum nor saline can produce any such prompt response as exudative material. The factor abbreviated as the LPF is thermolabile and nondiffusible. It can be extracted in the pseudoglobulin fraction of exudates by fractionation with $(NH_4)_2SO_4$. Recent cataphoretic studies in collaboration with Dr. Gerald Cooper and Mr. Dillon, of the Duke University School of Medicine, suggest its association with the α^1 and α^2 globulins of exudates. In as yet unpublished studies by the writer, it has been found that by aging the LPF the material seems to denaturate spontaneously, and then it becomes insoluble. The active principle, however, splits off from the original protein molecule as a soluble component, which in preliminary tests appears to be polypeptide in nature.

Alpha Omega Alpha Lecture delivered at the Woman's Medical College of Pennsylvania, Philadelphia, November 8, 1946. Presented also as a seminar before the Department of Biology, Bryn Mawr College, January 8, 1947.

The leucocytosis-promoting factor, or LPF, of exudates reasonably explains the mechanism of leucocytosis with inflammation. The LPF induces a discharge into the circulation of immature granulocytes. It is also present in human exudates, but, as already mentioned, it is absent from normal blood serum except when there is a concomitant acute inflammation.

The LPF has, likewise, a specific growth effect on some of the elements of the bone marrow. Its administration is rather quickly followed by a hyperplasia of granulocytes and of megakaryocytes. These various properties possibly imply some clinical application, for it is well known that the prognosis of infectious processes depends to a large extent on the number of circulating leucocytes.

Recent studies at Duke University indicate that the canine LPF is both innocuous and active on human beings (*Arch. Path.*, 1946, **41,** 376) when administered intravenously. New studies by the writer demonstrate that with an already-existing inflammation the superimposed intravascular introduction of a single injection of LPF induces a synergistic effect, so that the number of circulating leucocytes remains elevated for markedly longer periods (on the average, about 9 times longer) than in control animals with an inflammation alone or in animals which have received only a single injection of LPF. These studies definitely point toward clinical implications in an endeavor to reinforce the commonly used antibiotics. The LPF can be assayed conveniently on guinea pigs. The canine material is likewise promptly active on these animals, even when injected subcutaneously.

The reaction of injury with inflammation is basic and fairly stereotyped. It includes the four cardinal features of Celsus, the loss of function of John Hunter, and the chemical breakdown of proteins, namely, proteolysis. Although, as pointed out earlier, the irritant and the location of the lesion may alter its ultimate appearance, a basic similarity can, nevertheless, be roughly discerned. This injurious reaction by the tissues of the host has been found to be referable to the euglobulin fraction of the exudative material. There is thus liberated by injured cells a toxic substance which has been termed *necrosin*. Necrosin is either a euglobulin or is associated with this fraction of exudates. Its cutaneous injection is followed by swelling, redness, varying degree of central necrosis, lymphatic blockade, injury to the endothelial wall of blood vessels, and swelling of collagenous bundles. Necrosin is absent in normal blood serum, but it can be recovered frequently from the serum of an animal with a concomitant inflammation. This fact may be of significance in revising our views on so-called foci of infections, with their repercussions on organs at a distance. For this reason, observations were undertaken to determine the effect on various structures of intravascular injections of necrosin (*Arch. Path.*, 1943, **36,** 269). There is almost constant injury to the liver. This may be in the form of a curious stippling granulation in the hepatic cords, or the liver cells may display a prominent degree of vacuolation with scattered areas of leucocytic infiltrations. Dogs were also repeatedly injected intravascularly with this toxic material over a space of weeks. Large amounts of either glycogen or fat replaced a good deal of the normal hepatic tissue. These deposits of glycogen were found not to be referable to feeding. It has been found that injections into the circulating blood of exudative material or of necrosin induce a small rise in the blood sugar level. Whether this small but constant augmentation in sugar concentration is referable to the apparent specific effect of necrosin on the liver remains to be determined. Varying degrees of injury to the kidneys following necrosin injection may also occur.

The whole euglobulin fraction of exudates not only induces a conspicuous degree of cellular damage but also causes both a rise in temperature and a marked drop in the white cell count—a state of leucopenia.

By a method of differential solubility the fever-inducing factor has been dissociated from the true euglobulin fraction of usually acid exudate, which in turn is, or at least contains, necrosin (*Arch. Path.*, 1945, **39,** 28). This pyrogenic factor, which can reasonably explain the mechanism of fever with inflammation, has been termed *pyrexin*. It is capable of increasing the temperature of a rabbit or of a dog 2° or 3° F. It is a thermostable factor; boiling fails to inactivate it. It is conceivable that its action is central, for nembutal and antipyretics tend to reduce its action. Its frequent occurrence from nonpyrogenic necrosin by merely incubating the latter suggests that pyrexin may perhaps be the end-product of proteolytic degradation, especially since some protein enzymatic activity is found to be present in necrosin. It appears to be eliminated to some extent in the urine. Some studies in collaboration with Frederick Bernheim, of Duke University, indicate the possibility that pyrexin is a glycopeptide, but further studies are necessary before this view becomes a certainty.

The leucopenic factor of exudates seems to be closely associated with pyrexin. It can be dissociated from the latter by hydrolyzing it briefly with 0.1 N HCl and subsequently neutralizing it with N NaOH. The presence of such a factor in exudative material, particularly if the exudate is at an acid pH, may be of help in explaining the leucopenia attending numerous inflammatory processes, such as influenza and typhoid fever. The presence of this factor in exudates, probably liberated by injured cells, opposes the LPF in its mode of action. The actual level of white cells in the circulation may prove to be the resultant of these opposing tendencies on the part of the two different factors. The mode of action of the leucopenic factor, which appears to be a polypeptide, seems to be a trapping of leucocytes in various organs such as the alveolar walls of the lungs, the sinusoids of the liver, and

the spleen. The trapping of leucocytes in the spleen may help in our understanding of the mechanism of the acute splenic tumor which is frequently seen with many inflammatory processes.

I believe that sufficient material has been presented to stress the necessity of studying thoroughly the biochemistry of cells injured previously by an irritant. The several common denominators already identified in exudative material are shown in Fig. 1. Doubtless, further studies

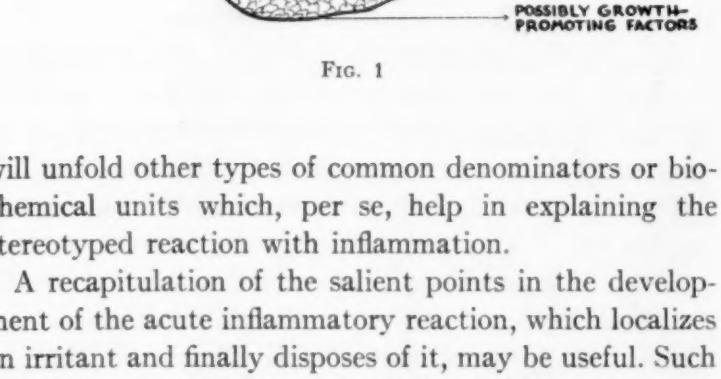

FIG. 1

will unfold other types of common denominators or biochemical units which, per se, help in explaining the stereotyped reaction with inflammation.

A recapitulation of the salient points in the development of the acute inflammatory reaction, which localizes an irritant and finally disposes of it, may be useful. Such an outline may be presented in brief as follows:

(1) *Disturbance in local fluid exchange:*
  (A) Increased capillary permeability, referable to liberation of leucotaxine, a crystalline nitrogenous substance.
  (B) Initial increase in lymph flow.

(2) *Localization of irritant (fixation)*, referable to lymphatic blockade by occluding thrombi and a fibrinous network at the site of severe inflammation:
  (A) The inflammatory reaction may be considered as the regulator of bacterial invasiveness, i.e. $D = \frac{Kt}{I}$ where D refers to dissemination; I, to degree of local injury; t, to time; and K is a constant.

(3) *Migration of leucocytes:*
  (A) Diapedesis of polymorphonuclear leucocytes referable to liberation of leucotaxine. In this way phagocytosis, stressed by Metchnikoff, can operate readily. The mechanism whereby macrophages assemble at the site of injury is still not exactly known.
  (B) Cytological sequence at the site of inflammation conditioned by the local pH, in turn referable to a disturbance in carbohydrate metabolism; glucose formed by injured cells by deamination of proteins.
  (C) Leucocytosis in the circulation, referable to liberation of a leucocytosis-promoting factor demonstrable in association with the pseudoglobulin fraction of exudates. The LPF induces a concomitant growth of granulocytes and of megakaryocytes in the bone marrow.

(4) *The pattern of injury in inflammation*, referable to the liberation of a toxic substance in the euglobulin fraction of exudates, termed necrosin. This fraction contains proteolytic activity.
  (A) Fever with inflammation, referable to liberation of pyrexin in exudative material.
  (B) Leucopenia with inflammation, possibly associated with the liberation of a leucopenic factor in exudates.
  Both pyrexin and the leucopenic factor are, with necrosin components, recovered from the euglobulin fraction of exudates.

(5) *Repair*, possibly referable to the liberation of one or several growth-promoting factors in exudates.

Obituary

John Lewis Sheldon

1865–1947

John L. Sheldon, former professor of botany at West Virginia University, died at his home in Morgantown on January 15, 1947. He had passed his declining years in seclusion, but retained to the last an active interest in his chosen science.

He was born at Voluntown, Connecticut, on November 10, 1865. He was educated in the elementary schools of Connecticut and was a teacher in the school system of the state from 1885 to 1890. From 1892 to 1894 he was an instructor in the Mt. Hermon School. After receiving the B.S. and B.Pd. degrees from Ohio Northern University in 1895, he again became a teacher in the Connecticut public schools, continuing in this position until 1898, when he began teaching in the preparatory school of the University of Nebraska. Proceeding with graduate work, he received the B.S. degree from Nebraska in 1899 and the M.S. degree from Ohio Northern the same year. During 1899–1900 he was a teacher in the Nebraska State Normal School. From 1900 to 1903 he was an instructor of botany at Nebraska, where he continued his graduate work, receiving the A.M. and Ph.D. degrees in 1901 and 1903, respectively. He was appointed professor of bacteriology at West Virginia University in 1903 and professor of botany and bacteriology in 1907. In 1913 he was designated as professor of botany, which position he retained until his retirement in 1919.

While at West Virginia University, Dr. Sheldon made many trips over the state, carefully studying the plant life and making extensive collections. His field work added a large number of species to the previously known flora of the state, many of which were published in Millspaugh's *Living flora of West Virginia* (1913). Although he was especially interested in cryptogams, he found time also to collect thousands of specimens of phanerogams. He was a collaborator of the Bureau of Plant Industry, U. S. Department of Agriculture, from 1902 to 1903 and from 1905 to 1922. A long bibliography of his botanical writings was published recently in *Castanea* (1939, **4,** 72–74). At the age of 74 he completed an exhaustive study of the lichens of West Virginia (see *Castanea*, 1939, **4,** 75–126).

He was a member of the American Association for the Advancement of Science, the Phytopathological Society, the Genetic Association, the Sullivant Moss Society, the Southern Appalachian Botanical Club, Sigma Xi, Phi Beta Kappa, and Phi Epsilon Phi.

He was a teacher of the classical school, and his enthusiasm was an inspiration alike to his students and associates. Throughout the long years of his retirement when failing health interfered with his normal pursuits, he retained his interest in his former students, and his friends were always heartily welcomed at his home.

EARL L. CORE

West Virginia University, Morgantown

Philip W. Schutz

1908–1947

Philip W. Schutz, professor of chemical engineering at the University of California, died at Permanente Hospital, Oakland, on March 7, 1947.

Dr. Schutz was born in St. Louis and received his education there through B.S. and M.S. degrees in chemical engineering at Washington University. He received the Ph.D. degree from the University of California in December 1933 and served as instructor at that institution until June 1934. After a year with the Shell Oil Company at Martinez, California, he returned to the University to serve as research associate to the late Gilbert N. Lewis for the period 1935–37. Then for three years he was instructor of chemical engineering at Washington State College, Pullman.

In 1940 Dr. Schutz went to Columbia University as assistant and later associate professor of chemical engineering. During the war years he served as consultant to the National Defense Research Committee and to the Manhattan Engineering District on several important projects. In 1946 he returned to the University of California as professor of chemical engineering.

The fields in which Dr. Schutz made his major scientific contributions and in which he was regarded as a leader were chemical and chemical engineering thermodynamics and dielectric heating. In the former field he published several papers with Wendell M. Latimer on the entropies of aqueous ions and with Gilbert N. Lewis on heavy water and deuterium compounds. Later he contributed to the general theory of azeotropic solutions and detailed data for several systems. Most recently he undertook a fundamental study of dielectric heating.

KENNETH S. PITZER

Department of Chemistry,
University of California, Berkeley

NEWS
and Notes

Paul A. Jenkins has been elected general chairman of the local committees directing preparations for the 114th meeting of the AAAS, to be held in Chicago December 26–31, 1947 (*Science*, April 18). As executive secretary of the Chicago Technical Societies Council, a federation of 50 local sections of scientific, engineering, and technological societies, he is eminently qualified to supervise convention arrangements. During World War II he was in charge of operations of the War Production Board in Northern Illinois, including Chicago. Prior to the war he was active in advertising and sales management.

On May 12 the chairmen of the subcommittees in Chicago met for the first time to report to the general chairman. The Equipment Committee had undertaken to survey the availability of meeting rooms in educational institutions near the headquarters hotels as the result of prospective charges of $6,000–$8,000 for the use of hotel session rooms. It was reported that all sessions of the convention may be accommodated in rooms made available at no charge either within the Loop or just a few moments distant by bus or streetcar, if the hotels cannot be dissuaded from charging for the use of their session rooms.

At this meeting George M. Schmeing, chairman of the Chemistry Department, Loyola University, assumed the chairmanship of the Reception and Entertainment Committee.

About People

J. Robert Oppenheimer, wartime director of the atomic bomb project at Los Alamos, New Mexico, and professor of physics, University of California and California Institute of Technology, has been appointed director of the Institute for Advanced Study, Princeton, New Jersey. He will succeed Frank Aydelotte, who will retire in September. Dr. Oppenheimer will continue as a member of the Joint Army-Navy Research and Development Board and as chairman of the general advisory committee appointed by President Truman to assist the Atomic Energy Commission.

Herman F. Mark, director of the Institute of Polymer Research and professor of organic chemistry, Polytechnic Institute of Brooklyn, has been invited to accept the Chair Franccki at the University of Liège, Belgium, for the academic year 1947–48. The guest professorship, which involves a six-month lecture tour of several Belgian universities, has previously been held by P. Debye, H. S. Taylor, A. Szent-Györgyi, and Victor Henry.

William C. Steere, professor of botany, University of Michigan, and editor of *The Bryologist*, has been appointed chairman of the Department to succeed H. H. Bartlett, who leaves this month to aid in rehabilitation work at the University of the Philippines. Dr. Bartlett will resume his position as professor of botany and director of the Botanical Garden upon his return to the University.

Edwin Y. Webb, Jr., Office of Technical Services, U. S. Department of Commerce, left for Germany April 10 to obtain detailed information on German technological developments in which American electronics and communications industries have expressed particular interest. Mr. Webb will investigate microdot photography; variable-speed facsimile monitoring equipment; automatic telegraph systems; gold-plated surfaces in glass-to-metal seals in electron tubes; velocity-modulated and cold cathode electron tubes; selenium photocells; Telefunken ceramic tubes; and powdered iron cores for high-frequency applications. The results of the investigations will be released to the public through the Office of Technical Services.

J. H. Van Vleck, chairman of the Department of Physics, Harvard University, was the principal speaker at the annual Sigma Xi public lecture at the University of Oklahoma on April 24. His subject was "Microwave Spectroscopy."

Donald B. McMullen, associate professor of preventive medicine and public health, University of Oklahoma School of Medicine, has been granted a two-year leave of absence to accept appointment as senior parasitologist with the Armed Services in Japan, where he will be attached to the 406th Medical General Laboratory, Tokyo.

Alfred W. Gauger, professor of fuel technology and director of the Mineral Industries Experiment Station, Pennsylvania State College, delivered the 21st annual Priestley Lecture Series April 21–25 at the College. The Priestley Lectures were established in 1926 as a memorial to Joseph Priestley and, since 1931, have been sponsored jointly by the local chapter of Phi Lambda Upsilon, honorary chemical society, and the Department of Chemistry. Dr. Gauger's subject was "Physical Chemistry and the Technology of Fuels."

Raimon L. Beard, entomologist, has returned to the Connecticut Agricultural Experiment Station after a year's leave of absence, during which he was with the Chemical-Biological Coordination Center, National Research Council.

Wendell M. Stanley, of the Rockefeller Institute, Princeton, New Jersey, winner of the 1946 Nobel Prize in chemistry (*Science*, November 22, 1946), will deliver the 1947 Edgar Fahs Smith Memorial Lecture in the auditorium of the University of Pennsylvania, Philadelphia, on June 5. Dr. Stanley will discuss "Recent Studies on Viruses."

Inaugurated in 1929, the lecture series was sponsored by the chemistry faculty of the University until World War II. With resumation of the series last year, the Philadelphia section of the American Chemical Society became co-sponsor with the University.

P. F. Scholander, research biologist, Swarthmore College, is attending conferences on zoophysiology at the University of Oslo.

S. R. Detwiler, professor of anatomy, College of Physicians and Surgeons, Columbia University, delivered the 16th annual James Arthur Lecture on the Evolution of the Human Brain at the American Museum of Natural History, New York City, on May 8. He spoke on "Structure-Function Correlations in Developing Nervous System as Studied by Experimental Methods."

Willy Baensch, from 1929 to 1945 professor of radiology and cancer research and director of the cancer hospital, Uni-

versity of Leipzig, has been appointed professor of roentgenology at the Georgetown University School of Medicine, Washington, D. C. Dr. Baensch, who was elected secretary-general of the International Congress of Radiology at the last meeting in Chicago in 1937, is co-author with Drs. Schinz and Friedl of the *Manual of roentgen diagnosis.*

Grants and Awards

The John Wesley Hyatt Award for the Advancement of Plastics, consisting of a gold medal and $1,000, was presented to John J. Grebe, director of the Physical Research Laboratory, Dow Chemical Company, Midland, Michigan, on April 23 for his work in the production of pure styrene and its polymerization. Robert R. Dreisbach, staff member of the same laboratory, received a silver medal from the Award Committee for his contribution to the development of styrene.

Gladys S. King, at the 94th annual meeting of the New Orleans Academy of Sciences, was awarded the 1947 Research Grant, contributed equally by the New Orleans Academy of Sciences and the AAAS, for a study of the effects of 2,4-D on plant growth substances in water hyacinth and alligator weed.

Albert F. Blakeslee, director, Genetics Experiment Station, Smith College, Northhampton, Massachusetts, was awarded the Gold Medal of the Massachusetts Horticulture Society at a meeting of the Board of Trustees on January 7 for his contributions in the field of genetics and his contribution as an author along botanical and horticultural lines. Recognition was also made of Dr. Blakeslee's initiation of the use of colchicine in plant breeding.

Sharp & Dohme, Inc., has announced the award of three new research grants and the renewal of a fourth. The new grants have been made to: O. P. J. Falk, consultant at the St. Louis City Hospital, St. Louis, Missouri, in support of a clinical study to evaluate caronamide as an adjunct of penicillin in the treatment of infectious diseases; C. M. Hendricks, El Paso Medical and Surgical Clinic, in support of an extensive clinical study on the use of tyrothricin and other preparations as an aerosol; and Marshall C. Cheney, physician in charge of student health, University of California, Berkeley, in support of research on the prevention of the common cold by means of respiratory vaccines. A grant to Tulane University was renewed to allow C. Gordon Johnson to continue research on clinical problems that involve sulfathalidine phthalylsulfathiazole and sulfamerazine in pre- and postoperative urinary tract infections.

Joseph M. Hill, director of the William Buchanan Blood Center, Baylor University, Dallas, Texas, and professor of clinical pathology at Southwestern Medical College, received the first Marchman Award for notable research in medicine at the annual dinner of the Dallas Southern Clinical Society, January 21. Dr. Hill won the award for his recent investigations of the Rh factor. Named for the first president of the Clinical Society, Oscard M. Marchman, the award will be made annually except in years when there are no outstanding candidates.

Norman Arnold Nielsen, metallurgical engineer in the Engineering Research Laboratory of the Du Pont Company's Experimental Station, Wilmington, received the 1946 Young Authors Prize at the spring meeting of the Electrochemical Society. The award is given annually to authors under 27 years of age for the best technical paper in the year's publications of the Society. Dr. Nielsen's winning paper, "Passivation of Stainless Steel," written with E. M. Mahla, also of the Du Pont Experimental Station, included an evaluation of the various treatments for increasing the resistance of stainless steel to corrosion.

W. W. Norton & Company is again offering the Norton Medical Award for book manuscripts written for the lay public by professional workers in the field of medicine. The Award, which offers $5,000 as a guaranteed advance against royalties, is not being limited to any one year, and there is no final date for submissions. Either complete manuscripts or detailed table of contents, together with 100 pages of manuscript, may be submitted. A descriptive folder giving full details of the terms of the Award may be secured on request from the Company at 101 Fifth Avenue, New York 3, New York.

The Washington Academy of Sciences, at a meeting March 20, presented certificates of award for outstanding achievement in the biological, engineering, and physical sciences to: Waldo R. Wedel, U. S. National Museum, for his contribution to knowledge of the prehistory of human ecology in the central great plains; Martin A. Mason, Beach Erosion Board, War Department, for erosion studies leading to successful Allied beach invasions during the war; and George W. Irving, Jr., U. S. Bureau of Agricultural and Engineering Chemistry, for service in biochemistry, especially antibiotics in tomato plants.

Colleges and Universities

An Electric Analog Computer will be part of the new Analysis Laboratory now being established at the California Institute of Technology, according to announcement by Gilbert D. McCann, associate professor of electrical engineering at the Institute, who is setting up the laboratory.

The new calculator, which will be made available to all interested industrial and engineering organizations as well as being used for research at the Institute, will be in partial operation by June 1 and is expected to be completed by August. Weighing approximately 33,000 pounds, the machine, including its control desk, will occupy some 1,000 square feet of floor space. The device was designed for the solution of complex mathematical problems in the field of algebra and calculus requiring an accuracy of the order of 1 per cent. It is particularly suited to solving engineering problems, including those of electrical circuits; applied mechanics; self-induced mechanical oscillations, such as airplane structure flutter, car shimmy, rail car stability; problems in thermodynamics, such as a general analysis of heat flow problems; speed controllers, voltage regulators; and angle position controllers, such as airplane stabilizers, guided missiles, gyro pilots, etc.

According to Dr. McCann, a similar computer is being built by Westinghouse.

Northwestern University has received a gift of $190,172, the first of several to total more than $500,000, from the Public Health Institute of Chicago for use in the projected $100,000,000 medical center on the University's Chicago campus. The fund will be used for expanded research in the field of venereal diseases, other public health problems, and medical education and for treatment and examination of patients in the medical school clinic. All equipment

and other physical property of the Institute, which ceases operation this year after 26 years of operation as a nonprofit center for the treatment of venereal diseases, will be given to the University for use in connection with the fund.

The center will also have a neuropsychiatric hospital, provided by a bequest of $1,500,000 from the late Mrs. Joy Morton; a 600-bed cancer hospital, which will be built by the Veterans Administration; and new structures to house several of the established Chicago hospitals.

Industrial Laboratories

William C. Ellenbogen, formerly with the York Corporation, York, Pennsylvania, has joined the research staff of the Smith, Kline & French Laboratories, Philadelphia.

Edgar A. Thronson, of the Du Pont Company, has been appointed assistant director of the Technical Division, Electrochemicals Department.

Robert W. Elkas, formerly a Fellow of the Purdue Research Foundation, Purdue University, has been appointed assistant director of Pharmaceutical Control, Sharp & Dohme, Inc., Philadelphia.

M. F. Gribbins, a member of the Chemical Division of the Ammonia Department staff at the Du Pont Experimental Station since 1942, has been appointed to the Technical Service Section of the Ammonia Department. He will be concerned principally with development work relating to fertilizers and dairy and cattle feeds.

A new all-weather approach light system, developed by the Westinghouse Electric Corporation, permits visibility through 1,000 feet of the thickest weather, when objects 50 feet away cannot be seen in daytime. The system is a supplement to radar and radio aids, and not a replacement, since its usefulness begins when a plane reaches the approach portal, 3,500 feet from the end of the runway. Up to this point, a pilot is guided by instruments.

The system includes flash units, giving up to 3,300,000,000 beam candlepower, for use in zero-zero daytime; controllable blaze units that can be set to emit a soft red glow of about 100 candlepower for use on clear, moonless nights; and stages of candlepower suitable for any intermediate weather conditions.

A partial installation of this system has been tested at the Cleveland Municipal Airport. Tests have shown that the transition from instrument approach to visual landing can be accomplished under any condition of fog. The first full system will be installed at New York City's Idlewild Airport within eight months.

Vladimir Kosma Zworykin has been elected vice-president and technical consultant of the RCA Laboratories Division, Radio Corporation of America. Formerly director of the Electronic Research Laboratory, Princeton, New Jersey, Dr. Zworykin joined RCA in 1930.

During the war he directed television and radar research. In radio and electronic research for RCA he invented the iconoscope, television's electronic "eye," and developed the kinescope, electronic picture tube of the television receiver. He directed research on the first commercially practical electron microscope, for which he received the Rumford Award of the American Academy of Arts and Sciences in 1941. For work on television Dr. Zworykin received the Howard N. Potts medal of the Franklin Institute, announced in March 1947.

Meetings

The Laurentian Hormone Conference of the AAAS will meet September 8–13, at the Ste. Adele Lodge, Ste. Adele Quebec.

During the meeting the following papers will be presented: "The Mechanism of Action of the Plant Growth Hormones," Kenneth V. Thimann, Harvard University; "The Biochemistry of Pituitary Growth Hormone," Choh Hao Li, University of California; "The Effects of Hormones, Vitamins and Other Substances on Adrenal Function and Lipid Metabolism," Robert H. Williams, Thorndike Memorial Laboratory, Boston City Hospital; "New Syntheses in the Field of Estrogens," K. Miescher, Ciba Limited, Basle, Switzerland; "Steroid Excretion in Health and Disease," Seymour Lieberman, Memorial Hospital, New York City (chemistry), and Konrad Dobriner, Memorial Hospital, New York City (clinical aspects); "Urinary Steroids in Adrenal Disease," H. L. Maxon, Mayo Clinic; "The Chemical Histology of Endocrine Glands," Edward W. Dempsey, Harvard University; "Localization of Radioactive Compounds in Tissues," C. P. LeBlond, McGill University; "The Biology of the Interstitial Cells of the Testis," Charles W. Hooker, Yale University; "The Testis in Human Hypogonadism," Warren O. Nelson, University of Iowa; "Some Observations as to the Role of Testicular Secretions," James B. Hamilton, Long Island College of Medicine; "Regarding the Gonadotrophic Gonad Axis in Men," Carl G. Heller, University of Oregon; "The Renal Pressor System and Hypertensive Disease," A. C. Corcoran, Cleveland Clinic Foundation; and "Hypertension as a Disease of Adaption," Hans Selye, University of Montreal.

Since facilities of the Lodge are limited, membership in the Conference is established by invitation. Applications for membership by active investigators in the hormone field will be received by the Committee on Arrangements and its advisory committee. The members of the advisory committee are: B. J. Brent, H. M. Evans, H. B. Friedgood, R. G. Hoskins, H. Jensen, F. Koch, I. T. Nathanson, L. T. Samuels, E. Schwenk, M. L. Tainter, and A. White. Applications for membership may be made up to June 30, 1947, and should state if reservations for family members are desired.

The American Society of Mechanical Engineers, meeting in Chicago June 15–19, has planned its program about the 1947 theme, "The Engineer's Responsibility in Increasing National Productivity." In addition to the presidential address on "Broader Vistas," by Eugene W. O'Brien, addresses will be given by C. E. Wilson, General Motors Corporation, Robert R. Wason, National Association of Manufacturers, and others. One feature of the Wednesday evening banquet will be the presentation of the 1946 Alfred Noble Prize (administered by the American Society of Civil Engineers) to Martin Goland, Midwest Research Institute, Kansas City, for his paper, "The Flutter of a Uniform Cantilever Wing," which also won the Association's Junior Award. The technical sessions, to number about 40, will include: a meeting sponsored by the power division and the nuclear energy application committee, June 17; a meeting co-sponsored by the American Rocket Society, June 18; and a session on industrial instruments and regulators, with the Engineering Institute of Canada participating. Additional subjects to be considered in technical sessions are: machine design, fuels, materials

handling, metals engineering, process industries, rubber and plastics, aviation, power, production engineering, heat transfer, railroads, oil and gas power, management, citizenship, and education.

The Committee on Medical Research of OSRD has announced the final disposition of the accumulated records of research carried on under CMR sponsorship during the years 1941–46.

Weekly Bulletin: Complete sets of the 78 issues of the CMR Weekly Bulletin, containing abstracts of the "open" and "restricted" reports received from CMR investigators and a subject index, entitled "Summary of Reports Received by the Committee on Medical Research," are being deposited in the following libraries: Beloit College Libraries; Boulder City Public Library; Brown University Library; California Institute of Technology Library; Carnegie Institute of Technology Library; Carnegie Library of Pittsburgh; Case School of Applied Science Library; Clarkson College of Technology Library; Clemson College Library; Cleveland Public Library; Colgate University Library; Colorado A. and M. College Library; Colorado School of Mines Library; Columbia University Libraries; Cornell University Library; Crerar Library, Chicago; Detroit Public Library; Duke University Library; Engineering Societies Library; Enoch Pratt Free Library; Georgia School of Technology Library; Government Printing Office, Washington, D. C.; Harvard College Library; Illinois Institute of Technology Library; Iowa State College of Agriculture Library; Johns Hopkins University Library; Joint University Libraries; Library of Congress; Library of the Franklin Institute of the State of Pennsylvania; Louisiana State University Library; Massachusetts Institute of Technology Library; Montana State College Library; New Mexico School of Mines Library; New York Public Library; North Carolina State College Library; Northwestern University Library; Norwich University Library; Ohio State University Library; Oregon State College Library; Pennsylvania State College Library; Polytechnic Institute of Brooklyn Library; Princeton University Library; Purdue University Library; Rensselaer Polytechnic Institute Library; Stanford University Libraries; State College of Washington Library; State University of Iowa Libraries; Texas Engineers Library; Texas Technological College Library; Libraries of the Universities of California, California (Los Angeles), Chicago, Cincinnati, Delaware, Denver, Florida, Idaho, Illinois, Kansas, Maryland, Michigan, Minnesota, Missouri, Nebraska, New Mexico, North Carolina, Notre Dame, Oklahoma, Oregon, Pennsylvania, Rochester, South Carolina, Tennessee, Texas, Utah, Virginia, Washington, and Wisconsin; Utah State Agriculture College Library; Virginia Polytechnic Institute Library; Washington University Library, St. Louis; West Virginia University Library; Western Reserve University Library; Woods Hole Oceanographic Institute Library; and Yale University Library.

Reprints: Bound and indexed sets of more than 1,000 reprints of published work done under OSRD-CMR contracts are being deposited with the following: Army Medical Library, Washington, D. C.; Boston Medical Library; Crerar Library, Chicago; Lane Medical Library, San Francisco; Library of the National Academy of Sciences, Washington, D. C.; Library of the New York Academy of Medicine; Library of the Philadelphia College of Physicians; and Tulane University Medical Library, New Orleans.

Malaria Reports: Indexed sets of the 734 numbered reports issued by the Board for the Coordination of Malarial Studies, as well as Army, Navy, British, and Australian malaria reports, have been deposited with the Library of Congress, the National Archives Library, and the Office of Technical Services, Department of Commerce. Photostatic copies of the reports can be purchased from the latter office.

Aviation Medicine Reports: A complete set of the 505 numbered reports issued by the National Research Council Committee on Aviation Medicine, including Army, Navy, and CMR reports, has been deposited with the Army Medical Library, Washington, D. C. Microfilm or photostatic copies of the reports that have been declassified may be purchased from the Library.

Final and Interim Reports of CMR Investigators: Copies of almost all of these reports are on file in the Office of Medical Records, National Research Council, 2101 Constitution Avenue, Washington, D. C. Although these reports will not be sent out on loan, they may be consulted in that office.

Fresh eggs of wild American birds, however common, are desired by Hugh B. Cott, Cambridge University Museum of Zoology, Cambridge, England, for use in connection with a detailed investigation of the palatable and biochemical properties of birds' eggs. Dr. Cott would like to receive a complete clutch in the case of smaller birds; in the case of larger birds, one egg per species would be sufficient. The eggs should be collected fresh (before incubation) and sent air mail. Dr. Cott will pay the cost of freightage.

Former Sanitary Corps officers, including those still on active duty, are urged to communicate with Col. M. J. Blew to provide information for completion of an accurate postwar roster and for preparation of an analysis and evaluation of the activities of the Corps during the war. The following information is desired: rank; date called to active duty; present rank or rank on separation; specialty (engineering, entomology, parasitology, bacteriology, chemistry, nutrition, etc.); a résumé of pertinent facts regarding active-duty assignments; academic and professional degrees; professional and honorary society affiliations; whether registered or certified, etc.; and any comments or suggestions desired.

Communications should be addressed to: Col. M. J. Blew, % National Society of Professional Engineers, 1359 Connecticut Avenue, N. W., Washington 6, D. C.

Make Plans for—

American Society of Heating and Ventilating Engineers, June 1–4, Coronado, California.

Institute of Food Technologists, June 1–4, Hotel Statler, Boston, Massachusetts.

American Society for the Study of Blood, organizational meeting, June 8, Hotel Claridge, Atlantic City, New Jersey.

American Institute of Electrical Engineers, summer general meeting, June 9–13, Montreal.

American Medical Association, centennial session, June 9–13, Atlantic City, New Jersey.

Meteoritical Society, 10th meeting, June 18–19, San Diego, California.

COMMENTS

by Readers

In reply to Dr. Wright's criticism (*Science*, 1946, **104**, 190) of our note on the cause of nonresolvability of compounds of the type CabcCabc when the two asymmetric carbon atoms have opposite configurations (*Science*, 1945, **102**, 508), we are of the opinion that the concept of nonsuperimposability of mirror images is not a "trick" or a mere analogy, but is the necessary and sufficient condition for the existence of optical activity. The type of asymmetry necessary for mirror images of a molecule or crystal to be nonsuperimposable also is necessary for the retardation of one form of circularly polarized light with respect to the other and the production of a rotation of the plane of polarization of the resultant plane polarized light.

The assumption that the theory of Boys or of Kuhn can be applied to each half of the molecule CabcCabc separately, and added together algebraically when restricted rotation exists, assumes that the extent of rotation of the plane of polarization is independent of the path through the molecule. The theoretical treatments of Boys and of Kuhn deal only with models containing a single asymmetric carbon atom. Boys (*Proc. roy. Soc. Lond.*, 1934, **A144**, 655) postulates that the tetrahedral sets are distributed entirely at random in order to deal with an isotropic medium, thereby implying that the rotations of the individual molecules depend on their orientation. Kuhn (*Trans. Faraday Soc.*, 1930, **26**, 297, 302) states specifically that the rotation produced by the asymmetric molecule is dependent on the orientation of the molecule with respect to the light ray falling on it. In the discussion of Wolf's paper on restricted rotation (*ibid.*, p. 352) Kuhn points out that the rotation of one group with respect to the other will change the rotatory power of the molecule.

Our whole argument in the case of the compounds of the type CabcCabc is based on the fact that rotation is restricted and that the two halves of the molecule have a definite orientation with respect to each other. When this orientation is such that the mirror image is superimposable, the rotation produced by the molecule will be zero, regardless of the angle of incidence of the ray; but if the orientation of the two halves of the molecule is such that its mirror image is not superimposable, the rotation will be dependent on the angle of incidence. In the latter case the average rotation of randomly distributed molecules will be finite, because turning the molecule 180° through any axis does not influence the sign or extent of rotation of the individual molecules. If one wishes to consider the effects of the two halves of the molecule, the orientation of the two halves in the first case is such that the extent of rotation of the incident ray by one half is equal and opposite to that by the second half regardless of the angle of incidence; but in the second case the orientation of the two halves is such that the rotatory contributions of the two halves are equal in only two directions. Accordingly, if rotation is sufficiently restricted, we should expect one inactive, one *d*, and one *l* form when the configurations of the two asymmetric carbon atoms are enantiomorphic. Furthermore, the active forms resulting from restricted rotation when the two asymmetric carbon atoms have like configurations would have different rotations.

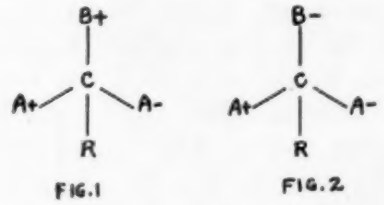

FIG. 1

FIG. 2

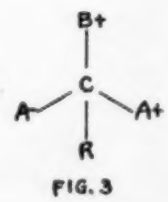

FIG. 3

FIG. 4

While there seems to be little hope of preparing α,β-dibromo-α,β-diiodosuccinic acid, which we suggested might be separable into active isomers, we believe that a somewhat similar case is subject to experimental treatment. Figs. 1, 2, 3, and 4 represent 4 of the 8 forms possible for compounds of the type CAABR, where A and B are asymmetric groups, and R is a nonasymmetric atom or group. The molecules represented by Figs. 1 and 2 are enantiomorphic, as are those represented by Figs. 3 and 4. Shriner and Adams (Gilman's *Organic Chemistry*, (2nd ed.), p. 239) suggest that molecules represented by Figs. 1 and 3 should differ in physical properties but have identical rotations. It is our opinion that the rotations will not necessarily be identical, and we have been working intermittently over several years on the preparation of diastereoisomers of this type. The same considerations apply to Figs. 2 and 4.

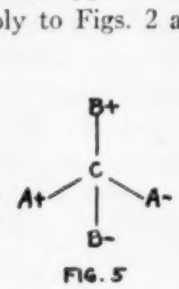

FIG. 5

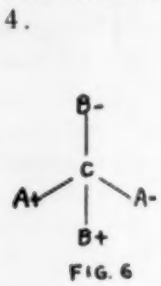

FIG. 6

An even closer analogy of the compounds of the type CabcCabc exists in the case of the forms of the compound CAABB, represented by Figs. 5 and 6. If the view of Shriner and Adams is correct with regard to the compound CAABR, then molecules corresponding to Figs. 5 and 6, which are enantiomorphs, should have zero rotation. It should be possible to synthesize compounds of this type also and decide the question by experimental results. (C. R. NOLLER, *Department of Chemistry, Stanford University.*)

Due to an oversight, in my article on "Origin and Evolution of Meiosis" (*Science*, March 14, 1947) the words meiosis and fertilization in diagram 5 were transposed. The reading should have been "*gametogenesis, fertilization, meiosis.*" (L. R. CLEVELAND, *Harvard University, Cambridge, Massachusetts.*)

TECHNICAL PAPERS

Inability of Thymine to Substitute for Folic Acid in the Rat

H. G. PETERING and R. A. DELOR[1]

Research Laboratories, The Upjohn Company, Kalamazoo, Michigan

Pteroyl glutamic acid or vitamin B_c (folic acid or liver *L. casei* factor) has been shown to be a growth factor for microorganisms and an essential nutritional factor in preventing and curing "folic acid" deficiency in the rat, chick, guinea pig, and monkey. This compound has also been shown to have therapeutic value in correcting the blood dyscrasias of Addisonian pernicious anemia and other macrocytic anemias.

Thymine (5-methyluracil) has also been shown by Stokes (*6*) to be a substitute for pteroyl glutamic acid in the nutrition of certain lactic acid bacteria when used in an amount 3,300 times the folic acid requirement. This microbiological work has been confirmed and extended to include other pyrimidines by Hitchings, Falco, and Sherwood (*1*) and by Krueger and Peterson (*2*). Even though the mechanism of this action of thymine was obscure and probably not identical with that of folic acid, its action in human anemias was tried on the basis of these microbiological data. Spies and his associates (*5*) have shown that large doses of thymine (4.5 grams or more daily) will cause remission from Addisonian pernicious anemia or other macrocytic anemias, thus indicating that in humans as well as in microorganisms thymine may be involved in folic acid nutrition in some obscure way.

The lack of any reports on the action of thymine in alleviating folic acid deficiency in experimental animals prompts us to report our inability to find it a useful substitute for folic acid in the prevention or cure of folic acid deficiency in the rat.

METHOD

The experimental procedures were essentially those used by Mallory, *et al.* (*3*) and Spicer, *et al.* (*4*). Twenty-eight-day-old rats of random sex having an average weight of 45–50 grams were fed ad libitum a purified diet containing 2 per cent succinyl sulfathiazole (sulfasuxidine). The basal diet consisted of 71 per cent sucrose, 18 per cent casein (Labco vitamin free), 3 per cent cottonseed oil, 2 per cent cod-liver oil, 4 per cent salts (Sure, *7*), 2 per cent sulfasuxidine, 0.1 per cent choline chloride, 0.1 per cent inositol, and 200 γ per cent vitamin K (dissolved in the cod-liver oil). Daily supplements were made in a cup as follows: thiamine hydrochloride, 200 γ; riboflavin, 100 γ; pyridoxine hydrochloride, 100 γ; calcium d-pantothenate, 200 γ; nicotinamide, 500 γ; and biotin, 1 γ.

The data of our experiments are summarized in Table 1. In Experiment 1, the supplements were given between the 28th and 42nd days, the first four weeks being the depletion period marked by definite growth plateau. In Experiments 2 and 3 the supplements were given from the first day. The indicated supplements were fed along with the crystalline B vitamins. Conventional hematological techniques were used in all blood analyses.

Only in Experiment 2 was a positive control employed, namely, 3 γ of crystalline folic acid[2] supplied daily to each rat in the group. The response in growth and in white blood cell and granulocyte counts in this experiment is typical of our experience with folic acid, supplied either as crystalline product or as yeast or liver concentrates. In curative experi-

TABLE 1

EFFECT OF THYMINE SUPPLEMENTATION ON "FOLIC ACID" DEFICIENCY IN RATS FED PURIFIED DIET PLUS SUCCINYL SULFATHIAZOLE

Supplement	Thymine daily (mg.)	Folic acid equivalent (γ)	Experimental day	Gain in weight (grams)	R. B. C. (cells/mm.^{3} × 10^{-6})	Hb (grams/100 ml. blood)	HMCT volume (%)	W. B. C. (cells/mm.^{3} × 10^{-3})	Granulocytes (cells/mm.^{3} × 10^{-3})	Survival
Exp. 1										
Negative	—	—	28	46.3	—	—	—	—	—	—
			42	40.7	—	—	—	4.9	0.074	8/9
Thymine	15	4.2	28	34.0	—	—	—	—	—	—
			42	35.5	—	—	—	6.52	0.163	2/5
Thymine	7.5	2.1	28	35.8	—	—	—	—	—	—
			42	22.4	—	—	—	3.80	0.057	4/5
Exp. 2										
Negative	—	—	36	46	6.42	12.3	36.8	5.63	0.113	10/10
Thymine	15	4.2	36	43	7.19	11.5	36.2	6.57	0.131	9/10
Thymine	25	7.0	36	45	6.22	11.4	35.3	7.71	0.231	9/10
Pteroyl glutamic acid	—	3.0	36	92	7.97	13.9	42.1	13.75	1.650	10/10
Exp. 3										
Negative	—	—	35	40.7	7.40	14.1	40.4	5.50	0.055	10/10
Thymine	12	3.5	35	34.6	7.59	14.8	43.8	4.51	0.018	10/10
Thymine + PABA (2 mg.)	12	3.5	35	53.5	7.65	13.9	40.7	5.80	0.087	10/10
PABA (2 mg.)	—	—	35	47.0	7.40	13.5	41.8	4.26	0.043	7/10

[1] The authors are pleased to acknowledge the assistance of H. B. Buskirk, Alice Bergdahl, Hallie Ferguson, and E. M. Stapert in carrying out the microbiological and hematological studies reported here.

[2] Supplied by E. L. R. Stokstad, of Lederle Laboratories, Inc.

ments similar to Experiment 1, we have found that 3 γ of folic acid given daily between the 35th and 49th days will allow a change in growth from about 93 grams to 140 grams, an increase in white cell count from about 4,000 to 10,000, and a change in the granulocyte count from about 300 to 1,000.

P-aminobenzoic acid has been previously tried for its effect on the syndrome produced with sulfasuxidine in rats fed a purified diet, but with little success. However, it was included in Experiment 3 to determine whether it might allow some subtle effect of thymine to be shown. This was not the case under our conditions.

Results and Discussion

Our data indicate that thymine has no curative or preventive effect on the course of folic acid deficiency in the rat with respect to either growth or any part of the blood picture, when it is fed daily in amounts equivalent to 2.1, 3.5, 4.2, and 7.2 γ of folic acid as determined microbiologically in our laboratory.[3]

In view of the striking observations reported by Spies, *et al.* in human patients (*5*), these results on rats are interesting. They point to the fact that thymine is not a true substitute for folic acid and indicate that when folic acid-like activity is shown by thymine, pyrimidines, or other preparations, some indirect mode of action must be operating. Such a viewpoint is in harmony with the fact that thymine is chemically very unlike folic acid.

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6. Stokes, J. L. *J. Bact.*, 1944, **48**, 201.
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Experimental Diabetes and Diet

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Instituto de Biología y Medicina Experimental, Buenos Aires, Argentina

The influence of different diets on sensitiveness to alloxan and experimental pancreatic diabetes in the white rat has been investigated.

Two hundred twenty-three female rats weighing between 90 and 120 grams were divided into several groups and fed different diets for a period of one month. At the end of the month and 12 hours after the last meal they were injected intraperitoneally with 160 mg./kg. of alloxan. The mortality rate was considered during one week after the injection, and in all cases high hyperglycemia preceded death.

[3] The thymine used in this work was chemically pure and found to have 280 γ of folic acid activity/gram.

The results were as follows (see Table 1):

(1) In the group given a high carbohydrate diet the mortality due to alloxan was 40 per cent.

(2) In the group given a low protein diet (10 per cent casein content) there was 90 per cent mortality. Increasing the protein content from 20 to 45 per cent increased the resistance to alloxan (40 and 33 per cent mortality).

TABLE 1

Diets	Wheat flour (%)	Corn flour (%)	Casein (%)	Fat (%)	Yeast (%)	Cod liver oil (%)	Salt mixture (McCollum Davis) (%)	No. of rats used	Mortality (%)
(a) High carbohydrate	35	34	20	0	5	5	1	15	40
(b) High protein	10	34	45	0	5	5	1	15	33
(c) Low protein	40	39	10	0	5	5	1	15	90
(d) High lard	10	25	20	34	5	5	1	20	100
(e) High lard and high protein	14	15	30	30	5	5	1	15	100
(f) High ox fat	10	25	20	34	5	5	1	14	86
(g) High lard, and methionine (200 mg./kg./day)	10	25	20	34	5	5	1	10	30
(h) High lard, and sulfanilamide (250 mg./kg./day)	10	25	20	34	5	5	1	10	90
(i) High lard, and choline (300 mg /kg./day)	10	25	20	34	5	5	1	15	100
(j) High lard, and thiouracil (200 mg./kg./day)	10	25	20	34	5	5	1	10	10
(k) High olive oil	10	25	20	34	5	5	1	15	40
(l) High butter	10	25	20	34	5	5	1	15	33
(m) High oleomargarine	10	25	20	34	5	5	1	15	21
(n) High corn oil	10	25	20	34	5	5	1	15	13
(o) High coconut oil	10	25	20	34	5	5	1	14	0
(p) High lard (30%) and coconut oil (10%)	9	20	20	40	5	5	1	10	20

(3) High lard and high ox fat diets decreased strongly the resistance to alloxan (100 and 86 per cent mortality, respectively). This effect was not modified in the former either by increasing the casein content from 20 to 30 per cent (100 per cent mortality) or by treatment with choline or sulfanilamide. In contrast, the treatment with methionine or thiouracil corrected the hypersensitiveness (30 and 10 per cent mortality, respectively).

(4) The sensitiveness to alloxan was not modified when high olive oil or high butter diets were administered (40 and 33 per cent mortality, respectively), but there was an increased resistance to alloxan in the rats fed either a high oleomargarine diet (21 per cent mortality) or in those fed a high corn oil diet (13 per cent mortality).

(5) Complete protection to alloxan in rats fed a high coconut oil diet (0 per cent mortality) was observed.

(6) In rats fed a high lard diet modified by the addition of 10 per cent coconut oil, a partial protection to alloxan was observed (20 per cent mortality).

The role of the quality of diets and the amount of food fed on the initiation and evolution of experimental pancreatic diabetes in rats has also been studied.

Fifty-one male rats weighing about 130 grams were subtotally pancreatectomized (95 per cent of the pancreas) and

divided into three groups, each of which was fed one of the diets shown in Table 1 (a, b, and d).

As shown in Table 2, the high protein diet showed a protective effect and the high lard diet an unfavorable effect in comparison with that which was high in carbohydrate.

TABLE 2

Time after operation (mos.)	High protein diet		High carbohydrate diet		High fat diet	
	Diabetes		Diabetes		Diabetes	
	Total	%	Total	%	Total	%
1	4/16	25	2/18	11.1	7/17	41.1
2	9/16	56.2	14/18	77.7	17/17	100
4	10/16	62.5	15/17	88.2	15/15	100
5	10/16	62.5	12/13	92.3	15/15	100
6	11/15	73.3	11/12	91.6	14/14	100
7	11/15	73.3	11/11	100	10/10	100
8	9/12	75.0	10/10	100	5/5	100

In overfed rats (fed three times daily with a high carbohydrate diet) the evolution of diabetes was much faster than in those fed once a day and eating less food. Furthermore, the same diet but restricted in quantity (about 80 per cent of the amount of food eaten by a normal rat) produced a marked delay in the time of initiation of diabetes (see Table 3).

TABLE 3

Time after operation (mos.)	Underfed		Overfed		Ad libitum	
	Diabetes		Diabetes		Diabetes	
	Total	%	Total	%	Total	%
1	1/13	8	4/17	23.5	2/18	11.1
2	5/12	41.6	15/15	100	14/18	77.7
4	3/7	42.8	10/10	100	15/17	88.2
5	1/7	14.3	7/7	100	12/13	92.3
6	4/7	57.1	5/5	100	11/12	91.6
7	3/7	42.8	3/3	100	11/11	100
8	3/7	42.8	3/3	100	10/10	100

Diabetes appeared first in those rats which received their food once a day (in a quantity proportional to their body weight) rather than in those receiving the same amount of food divided into three feedings at 7-hour intervals. It may be supposed that the higher postprandial hyperglycemia of the former diet exerts an unfavorable effect, whereas the postprandial hyperglycemia resulting from the latter is less intense.

Summary

In the experiments described the following observations have been made:

(1) The toxic and diabetogenic action of alloxan increases in rats fed a low protein diet and even more so in the case of a high lard or ox fat diet.

(2) The action of these fat diets was corrected by the addition of methionine, thiouracil, or coconut oil, but there was no modification either by addition of choline or sulfonamide or by increase in the protein proportion.

(3) In rats fed other high fat diets (olive oil, butter) the actions of alloxan were not modified, but there was a slight diminution when high oleomargarine or corn oil diets were fed. However, complete protection was observed when a high coconut oil diet was administered.

(4) The unfavorable effect of the high lard diet was observed also on the initiation and evolution of diabetes due to subtotal pancreatectomy. Contrarily, feeding a high protein diet and especially treatment with thiouracil had a favorable effect.

(5) Diabetes appeared first in subtotal pancreatectomized rats which were overfed, then in those which ate ad libitum, and finally in those which were underfed. Diabetes appeared in rats fed a single meal before it did in those eating the same amount of food divided into three meals.

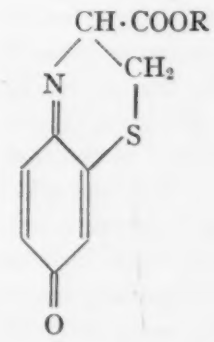
Mechanism of the Antibiotic Action of Certain Quinones

Otto Hoffman-Ostenhof

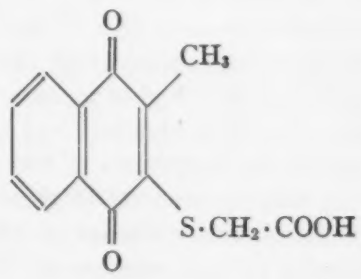
1st Chemical Laboratory, University of Vienna, Austria

A widely accepted theory suggests that many antibiotics function chiefly because of their ability to interfere with the sulfhydryl groups of enzymes concerned in bacterial metabolism (*2*).

In a recently published report by Colwell and McCall (*3*) it is claimed that the inhibition of bacterial and fungus growth by 2-methyl-1,4-naphthoquinone and related quinones also is due to a reaction of the quinones with sulfhydryl compounds. This theory is supported by the fact that excess amounts of sulfhydryl compounds are able to suppress the antibiotic properties of 2-methyl-1,4-naphthoquinone. Kuhn and Beinert (*8*) have shown that p-benzoquinone and cysteinethylester-hydrochloride react by addition of the —SH compound to a free position in the quinone molecule; in two further steps a condensation product (I) is formed. Fieser and Fieser (*4*) describe the reaction between 2-methyl-1,4-naphthoquinone and thioglycolic acid, where an addition product of the formula (II) is formed.



(I)



(II)

As far as quinones are concerned, the theory described is, however, not a satisfactory one. As Colwell and McCall (*3*)

state, it does not explain the antibacterial and antifungal potencies of 2-methyl-3-methoxy-1,4-naphthoquinone, because this quinone has no free position on the quinone side of the molecule. Oxford (*9*) has shown that among p-benzoquinone derivatives the spinulosin-trimethylether (trimethoxytoluquinone) is one of the strongest bacteriostatics of this group; certainly, no possibility of addition exists in this compound. The effect of excess amounts of sulfhydryl compounds on the bacteriostatic potency of some quinones does not prove conclusively the existence of a specific antagonism between quinones and —SH groups. The inactivation of the quinones can be achieved by excess amounts of other strongly reducing substances (e.g. sodium bisulfite) as well.

Quinones are very reactive substances. In experimental work done in this laboratory (*6*), the inhibitory potency of many quinone derivatives on some enzyme systems (urease, papain, catalase, etc.) was tested. It was found that some of the very strongest antibiotics had no, or nearly no, effect on the activity of these enzymes. In the case of urease and papain, certainly —SH groups, which function as activating groups for the enzymatic process, are involved. A certain parallelism between antibiotic properties and inhibitory potency on urease and papain should be expected, if really the reaction with sulfhydryl compounds would be the dominant mechanism of the antibiotic action. By the same experiments it was shown that some enzymes, in which certainly no sulfhydryl groups play any role, also are inhibited by quinones. Of course, the inhibition of enzymes without —SH groups also could be one of the means by which the quinones exert their antibiotic effects. It is also known that quinones can react with amino groups of proteins and amino acids; the tanning properties of p-benzoquinone are used in industry to a certain extent (*5*). It could be imagined that, by tanning the protein compounds of the bacterial cellular membranes, normal cell division could be inhibited. Another possible mechanism can be derived from the relatively elevated oxidation-reduction potential of most of the quinones. Wieland (*10*) has demonstrated that p-benzoquinone is a strong inhibitor of some dehydrogenases. Thus, quinones could act as antibiotics by interfering with bacterial respiratory enzymes and thereby inhibit the synthesis of essential cell components.

The theory that the mode of antibiotic action of the quinones is a complex one can be supported by the fact that some of the quinones with strongest bacteriostatic potency on *Staphylococcus* have very little effect on *Escherichia coli* or on some species of yeast as *Saccharomyces cerivisiae* or *Torula utilis* (*7*), while other quinone derivatives, whose toxicity on *Staphylococcus* is quite negligible, exert rather strong effects on the other organisms mentioned. In experiments with *Planaria gonocephala* we were able to show that, using one compound, it was possible to distinguish two different dominant factors, progressing from higher to lower concentrations of the toxic agent. The data obtained lead us to believe that the effect of higher concentrations of the quinones is dominantly due to the tanning property of these compounds, while in lower concentration the quinones exert their antibiotic effects by the inhibition of some enzyme of the organism, most probably some of the oxidative-reductive enzymes.

The experiments mentioned suggest clearly that the antibiotic action of the quinones is not due to a single reaction, but to a very complex mechanism. The mode of action proposed by Colwell and McCall is certainly only one of the means by which the quinones exert their effects and, in most cases, seems not to be the dominant one.

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Virus Hemagglutination[1]

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The phenomenon of virus specificity is a familiar biological problem, but, with the possible exception of the bacteriophage group of viruses, the nature of the factors responsible for this specificity has not been clearly defined. With respect to the bacteriophage there is evidence that the virus unites with a specific component on the cell—in the case of *coli* and coliphage, for instance, with an antigenic surface polysaccharide (*5*). In the animal virus group, Curnen and Horsfall have shown that the P.V.M. virus can unite with some cellular component of lung tissue (*2*). The combining material was described as tissue particles.

It is evident that accurate characterization of the specific combining tissue components, especially with respect to their structural chemistry, might lead to an understanding of virus specificity in terms of chemical or metabolic relations between the virus and cell. In this connection it was thought that one possible approach to the problem would be the elucidation of the factors responsible for the hemagglutination phenomenon first described by Hirst (*3*) and studied further by Burnet, McCrea, and Stone (*1*) with respect to the alteration of cell receptors by virus action. The results of some preliminary studies along these lines are the subject of this communication.

From red blood cells[3] which are specifically agglutinated by certain viruses it has been found possible to prepare lipid

[1] Aided by a grant from the National Foundation for Infantile Paralysis, Inc.

[2] Fellow of National Health and Medical Research Council of Australia.

[3] Human red cell residues from plasma fractionation were kindly supplied by the Antitoxin and Vaccine Laboratory, Massachusetts Department of Public Health.

extracts capable of inhibiting the hemagglutinating action of the same viruses for these cells. The effect is presumably due to competitive combination of the extract with the virus. Comparison of Rows 4, 5, 7, and 8 with 1 and 2, and Rows 13 and 14). On the other hand, both human and sheep inhibitors interfered with the action of mumps virus[4] on human and chicken cells (compare Rows 7 and 4 with 1 and Rows 8 and 5 with 2). Both human and sheep inhibitors also inter-

TABLE 1

Row	Virus	Inhibitor source	Red cells	Dilution of virus								
				1/1	1/2	1/4	1/8	1/16	1/32	1/64	1/128	1/256
1	Mumps	Saline	Human	+++	+++	+++	+++	+++	++	−	−	−
2	"	"	Chicken	+++	+++	+++	+++	+++	+++	+	−	−
3	"	"	Sheep	+++	+++	+++	+++	+++	+++	+	−	−
4	"	Sheep R.B.C.	Human	+	+	±	−	−	−	−	−	−
5	"	"	Chicken	+++	+++	+++	+++	+	−	−	−	−
6	"	"	Sheep	+++	+++	+++	+++	+++	+++	+	−	−
7	"	Human R.B.C.	Human	−	−	−	−	−	−	−	−	−
8	"	"	Chicken	−	−	−	−	−	−	−	−	−
9	"	"	Sheep	+++	+++	+++	+++	+++	+++	−	−	−
				1/25	1/50	1/100	1/200					
10	"	Sheep #2	Sheep #2	+	−	−	−					
11	"	Human	Sheep #2	+	−	−	−					
12	"	Saline	Sheep #2	+++	+++	+	−					
				1/1	1/2	1/4	1/8	1/16	1/32	1/64	1/128	1/256
13	PR 8	Saline	Human	+++	+++	+++	+++	+++	+++	+++	+++	+
14	"	Saline	Chicken	+++	+++	+++	+++	+++	+++	+++	+++	+
15	"	Sheep R.B.C.	Human	+++	+++	+++	+++	+++	+++	+++	+++	−
16	"	"	Chicken	+++	+++	+++	+++	+++	+++	++	++	+
17	"	Human R.B.C.	Human	++	±	−	−	−	−	−	−	−
18	"	"	Chicken	−	−	−	−	−	−	−	−	−

17 and 18 with 13 and 14 in Table 1, indicates the extent of inhibition in a typical experiment. In these experiments 0.2 cc. of saline emulsion of the inhibiting material was mixed with serial dilutions (0.2 cc.) of allantoic fluid of chick embryos infected with virus, and the mixture was allowed to stand at 2° C. for 30 minutes. One-tenth cc. of 2.5 per cent suspension of red cells was then added, the mixture was thoroughly shaken, and the cells were allowed to settle. The degree of agglutination was read by the method of Salk (*6*).

The inhibition reactions thus far tested seem to demonstrate specificity corresponding to that shown by the viruses in their hemagglutinating actions. Thus, it is known that influenza virus will agglutinate human and chicken red blood cells, but not sheep cells, whereas mumps virus will agglutinate human, chicken, and sheep red cells. Assuming structural similarity or identity between the cell receptor and the inhibitor molecule, it would then be expected that human inhibiting extract would be active against both influenza and mumps viruses, but that sheep inhibitor would only be active against mumps virus and inactive against influenza virus. Corresponding to these expectations it was found that human inhibitor prevented the hemagglutinative action of influenza on both human and chicken red cells (compare Rows 17 and 18 with 13 and 14 in Table 1), whereas sheep inhibitor had no effect on the influenza virus (compare Rows 15 and 16 with fered with the action of mumps virus on sheep cells, but this effect was often weaker and not obtained as invariably as were the other inhibitory effects (compare Rows 9 and 6 with 3, and Rows 10 and 11 with 12).

TABLE 2

Time of contact before removal of aliquot	Final dilution of virus							
	1/2.5	1/5	1/10	1/20	1/40	1/80	1/160	1/320
1 min	−	−	−	−	−	−	−	−
30 "	+	−	−	−	−	−	−	−
60 "	++	−	−	−	−	−	−	−
120 "	++	+	−	−	−	−	−	−
240 "	+++	++	+	±	−	−	−	−
Virus at room temperature 4 hrs.	+++	+++	+++	+++	+++	+++	++	−
Inhibitor at room temperature 4 hrs.	−	−						

+ = agglutination.

On prolonged contact of virus and inhibitor at 25° C. or 37° C., interaction between the two resulted in progressive inactivation of the inhibitor, evidenced by reappearance of increasing hemagglutinative activity in an inactive mixture (Table 2). In this experiment influenza virus and human in-

[4] Egg adapted strain kindly supplied by J. F. Enders.

hibitor were mixed and allowed to stand at room temperatures. Aliquots were removed at various intervals, serially diluted, and tested for hemagglutinating activity on human cells. The results are reminiscent of Hirst's description of reversal of hemagglutination (*4*) of cells, accompanied by elution of active virus and loss of cell susceptibility to further agglutination by the same virus. This similarity lends further support to the notion that the inhibitor is a derivative of, or identical with, the cell receptor. Influenza inhibitor has also been obtained from human lung.

Further details of this work and other related aspects of the problem, now under investigation, will be the subject of later communications.

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Reconsideration of the Photosynthetic Mechanism in *Chlorella*[1]

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Photosynthesis has been classically identified with the formation of carbohydrate. Theories of photosynthesis have frequently postulated a series of photochemical steps operating at all levels of reduction from carbon dioxide to carbohydrate. An a priori assumption in all such theories is that some form of carbohydrate is the direct product of the photochemical reactions. This viewpoint is consistent with data on photosynthesis in higher plants. For example, the elemental analysis of a corn plant indicates that its dry weight corresponds to almost pure carbohydrate (*3*); in short-time experiments on sunflower leaves the carbon dioxide taken up can be recovered quantitatively as carbohydrate (*6*).

Because of experimental advantages the green alga, *Chlorella pyrenoidosa*, has found wide use in studies on photosynthesis. No fundamental differences have been found between its photosynthetic behavior and that of higher plants. However, elemental analysis of the dry material of *Chlorella* is quite different than that of a higher plant, *i.e.* the nitrogen content is 8–10 per cent. As in the closely related colorless alga, *Prototheca* (*1*), the cell constituents may be considered to be about half protein and half carbohydrate. In close approximation, all the products of photosynthesis result in cellular materials. It follows that in a growing culture of *Chlorella* protein and carbohydrate syntheses must proceed at about equal rates.

The rapid synthesis of proteins (or other nitrogenous compounds) is borne out by studies of the assimilatory quotient as affected by the source of nitrogen supplied (nitrate or ammonium ion). Data obtained in manometric experiments by the usual procedures are summarized in Table 1.

[1] Supported by a grant from the University of Texas Research Institute.

The assimilatory quotient is affected by the light intensity during measurement as well as by the nitrogen source. The effect is correlated with the following observations. Up to ~ 50 f.-c., rate of growth is proportional to light intensity and to the measured rate of gas exchange. At higher light intensities (e.g. ~ 600 f.-c.) the cells may show a much higher rate of gas exchange, but they do not grow any more rapidly than at 100 f.-c. (*4*). Although complete explanation of these phenomena is not yet available, it appears to be related to differences in the comparative rates of carbohydrate and protein syntheses which depend upon light intensity and the previous history of the cells. Discrepancies between the quotients reported here and those found by other workers may be explainable in the same way.

TABLE 1

Assimilatory Quotient (CO_2/O_2, Exchange Ratio) Under Light-limiting and Light-saturating Illumination as Affected by the Nitrogen Source

Nitrogen source	Illumination	
	40 f.-c.	600 f.-c.
NO_3^-	−0.5	−0.8
NH_4^+	−0.9	−0.9

It has already been shown that starved cells of *Chlorella* will bring about an oxidative assimilation of acetic acid or glucose to what appears to be storage carbohydrate (*5*). This means that the processes of dark metabolism are able to effect synthesis of storage materials from respiratory intermediates. The accumulating products of photosynthesis also have been shown to be storage materials (*5*). Growing cells of *Chlorella* require protein and carbohydrate syntheses at approximately equal rates. These syntheses may result either from photosynthesis or from oxidative assimilation of an organic substrate in the dark. It is certainly reasonable to expect similarities in the pathways of the two modes of synthesis. We therefore offer, and shall further investigate, the following hypothesis: In photosynthesis the photochemical product is some intermediate, not itself carbohydrate, which may be converted subsequently to carbohydrate or to protein by metabolic pathways similar to those of heterotrophic forms.

We are well aware that this hypothesis has certain relations to, and apparent conflicts with, other theories and experimental data (e.g. *2*). There are also important implications of the low quotient at low light intensities with regard to past measurements of photosynthesis, in which a quotient of −0.9 has often been assumed. Experimental details, more complete data, and a consideration of their implications, will be reported elsewhere.

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IN THE LABORATORY

Methods for Increasing the Value of Hydra as Material in Teaching and Research

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In the course of an investigation in which *Hydra fusca* was used it became necessary to secure known and controllable environmental conditions in which the organism would exhibit normal behavior. This necessitated discarding the usual "pond water" and substituting a known solution as the environmental fluid. During the progress of trials to this end certain observations were made which may prove of use in facilitating classroom culture of, and demonstrations with, this form and also in enhancing its value as experimental material.

Hydra from cultures collected locally or from cultures obtained from Woods Hole, when transferred to a saline solution[1] made with ordinary distilled water from the laboratory supply, went into "depression" (*i.e.* exhibited continuous contraction followed by loss of tentacles, leading often to final disintegration), beginning a few minutes after transfer.

If distilled water of great purity, triple distilled from glass, was used, this did not occur, and the hydra remained normal. Neither did it occur immediately if a small amount of the culture fluid was added to the saline made with the ordinary distilled water. However, the addition of crystalline egg albumin, at the rate of 0.2 cc. of a 3 per cent albumin solution/100 cc. of the saline, was found to give complete protection for several days (3 at least), under survival conditions.

Experiments indicate that the toxic action of the water is probably due to substances such as traces of heavy metals, which are effective in extremely low concentration. Copper was found to be toxic within a few hours when present in a molar concentration of 5×10^{-7}. The action was completely prevented by albumin at 1:50,000, possibly even less. Tests indicate that this protective action is most probably the result of removal of the toxic material by adsorption on, or combination with, the albumin.

Hydra in solutions containing sufficient albumin show very fully stretched bodies with the tentacles extended to their maximum length, giving a display seen only rarely.

While the foregoing treatment will eliminate the need for exceedingly pure water in making cultures or class demonstrations, it was realized that a preparation of crystalline egg albumin is not readily available to all, so a few experiments were tried using filtered egg white. This will serve for classroom use. The amount needed will have to be ascertained by trial and error.

It is not necessary, at least over periods of a few hours, to use a saline solution. Distilled water shaken with a little egg white will serve to maintain the exhibition.

Another demonstration readily made under these conditions is vital staining with methylene blue. It was found that by increasing the concentration of albumin the toxic action of the dye was so reduced that deeply stained specimens showing little, if any, symptoms of damage could be made. For this the albumin concentration should be increased about 5-fold. A solution of the dye of 1:30,000 is tolerated. If, after staining, the hydras are kept for 12 hours in a solution lacking the dye, all the dye will be found in the endoderm, leaving the ectoderm colorless except for the cnidoblasts. These show as minute, dark blue dots.

Hence, by the use of these simple techniques, classroom cultures may be kept more easily, and demonstrations of the phenomenon of depression, recovery therefrom, the beauty of the fully extended animal, and the tissue layers may be easily made in the living state.

The ability to keep hydra in good condition in a known environmental medium will greatly increase its value as research material.

[1] The saline contained KCl, 0.002 gram; NaCl, 0.05 gram; $CaCl_2$, 0.003 gram; and $NaHCO_3$, 0.002 gram/1,000 cc. distilled H_2O.

Electron Micrographs of X-Ray–treated *Escherichia coli* Cells

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Ever since Muller (*14*) produced mutations in *Drosophila* by X-rays, this method has been adopted in the study of mutations in many other organisms, including microorganisms. Beadle's work (*1*) on X-ray mutants of *Neurospora* has not only given us many new ideas of the metabolism of this fungus, but it has also been a contribution to fundamental ideas of genetics. Euler, Ahlstrom, and Hogberg (*5*) X-rayed yeast cells to produce genetic changes, including formation of giant cells.

FIG. 1. X-ray-treated *E. coli* cell which has become elongated (ordinary microscope).

The effect of X-rays on bacteria has been studied by a number of investigators since shortly after Roentgen's discovery of the rays. Newcomer (*15*) in 1917 noticed that X-rays had a bactericidal effect on *Eberthella typhosa*. Clark and

Boruff (*2*) measured the lethal effect on *Bacillus coli* and *Erythrobacillus prodigiosus*, as well as destruction of the ability of the latter to produce the characteristic red pigment. Drea (*4*) attenuated *Mycobacterium tuberculosis* by the use of X-rays. Several geneticists, including Demerec (*3*), have used X-rayed bacterial cells in their studies on the phenomenon of mutation.

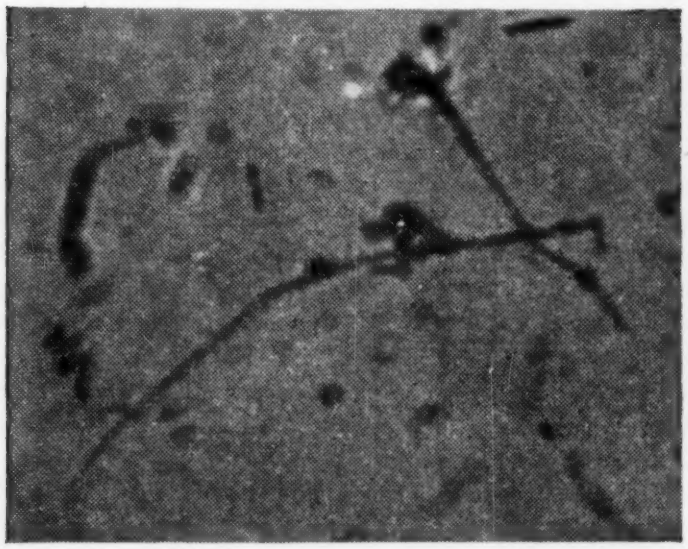


FIG. 2. X-ray-treated *E. coli* cells which have become elongated (ordinary microscope).

Lincoln and Gowen (*13*) studied several mutations produced by X-rays in *Phytomonas stewartii*. Haberman and Ellsworth (*8*), in a similar investigation on *Staphylococcus aureus* and *Serratia marcescens*, noticed the formation of elongated cocci into chains, instead of the usual grape-like or packet groupings.

It has been observed, in X-ray–treated bacteria, that the organisms sometimes lose their ability to multiply but are not dead. As early as 1917, Kempster (*10*) noticed that his X-rayed

FIG. 3. Section of X-ray–treated *E. coli* cell which has become elongated (electron micrograph). Note mottled appearance.

bacilli were not destroyed, although they failed to multiply. Often, these X-rayed bacteria which have lost their ability to multiply continue to grow into unusually elongated cells. Lea, Haines, and Coulson (*12*) made a careful study of these giant bacteria, and Evelyn Wilkin (*17*) observed the phenomenon in her mutation studies of *E. coli*. Explanations for cell elongation after irradiation, without division, are offered by Hollaender (*9*), Rahn (*16*), and Lea, Haines, and Bretcher (*11*).

Gray, Marton, and Tatiun (*7*), who made an electron microscope study of X-ray–produced mutants of *Acetobacter*, observed bulges in the mutants, which they interpreted as high concentrations of nucleoprotein.

The purpose of our investigation was to examine these irradiated, elongated cells under the electron microscope and study the ways in which they might differ from normal bacterial cells. Irradiation at 50 kv. and 20 ma. produced the irregular morphology. Figs. 1 and 2 show elongated *E. coli* cells as they appear under the ordinary microscope. Except for the elongation, the appearance is the same as that of the

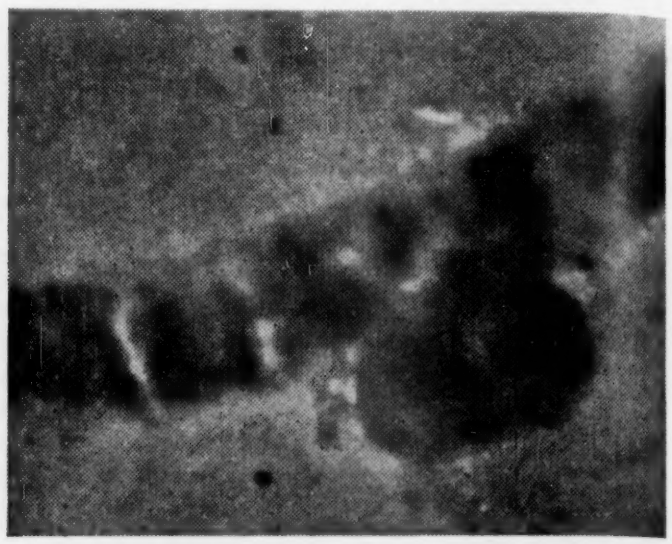


FIG. 4. Section of X-ray–treated *E. coli* cell (electron microscope). Note irregular appearance.

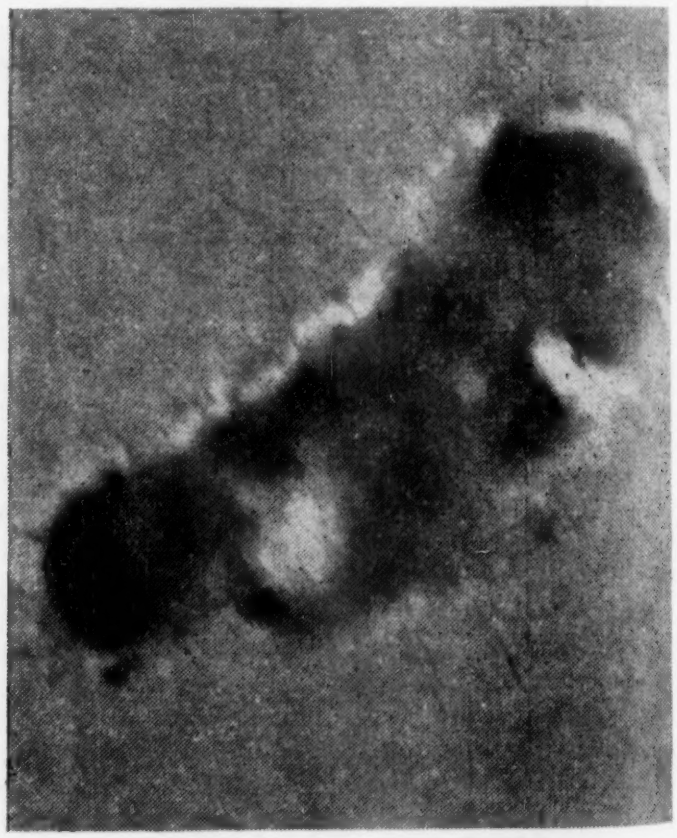
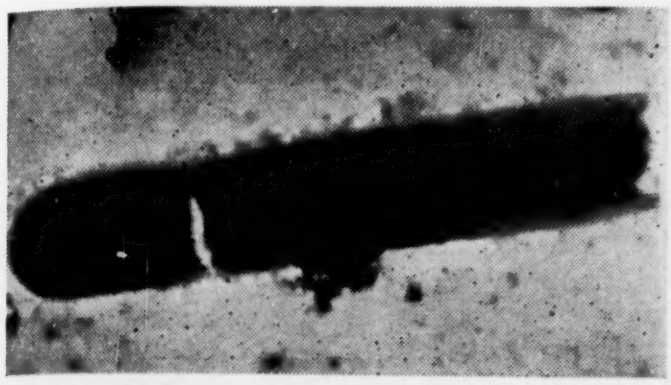


FIG. 5. X-ray–treated *E. coli* cell (electron microscope). Note irregular appearance.

normal cell. However, under the electron microscope, the elongated cells show characteristics not observed in the normal cell. As may be seen in Figs. 3, 4, and 5, some of these cells have a definitely mottled and irregular appearance, certain

areas being less dense than the remainder of the cell. In Fig. 6, which shows parts of the same cell, another unusual feature may be seen. Some of the elongated *E. coli* show definite "breaks" in the cell, perhaps at the place where the cell would have divided normally. Gates (*6*) reported that his irradiated

A



B

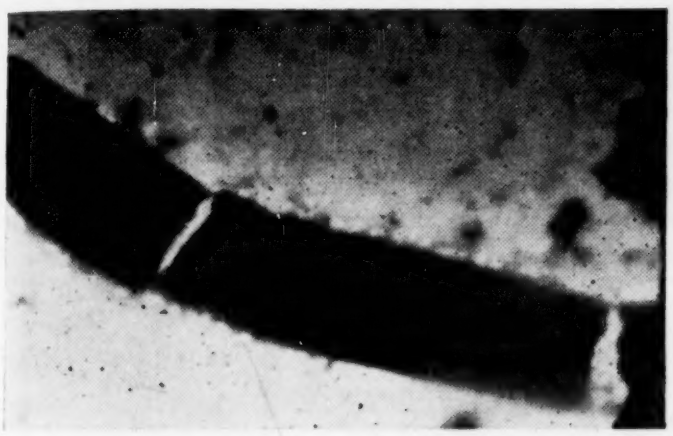


FIG. 6. A: X-ray-treated *E. coli* cell (electron microscope). Note periodic "break" in cell; B: part of same cell.

bacteria broke up into units, which then degenerated without further growth. Fig. 6 may be an indication of this type of behavior.

A possible explanation for "breaks" in the cell is that the enzyme which is responsible for the pinching off of the cell wall in normal bacterial fission has been destroyed by X-rays while other enzyme systems continue to function.

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A Mirror Device for Studying Lower Surfaces of Small Objects Using a Dissecting Microscope

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The problem of viewing all sides of a minute object such as a small flower, a small insect, and the like can often be not only difficult but exceedingly exasperating. The writer has for some time been studying a group of plants, the flowers of which are not over 3 mm. in size. A binocular microscope was necessary for accurate study of these. In order to count parts, observe arrangement, etc., it was necessary, after observing the upper surface, to turn the flower over painstakingly for a view of the lower surface. This method was very unsatisfactory because of time wasted, the possibility of losing the object, and the uncertainty arising from inability to see the entire object at the same time.

Recently, however, a solution to this problem has presented itself and is described here with the hope that it may be of use to other workers faced with similar problems. The device is quite simple and can be constructed in a few minutes by anyone. The model which has been used by the writer (Fig. 1)

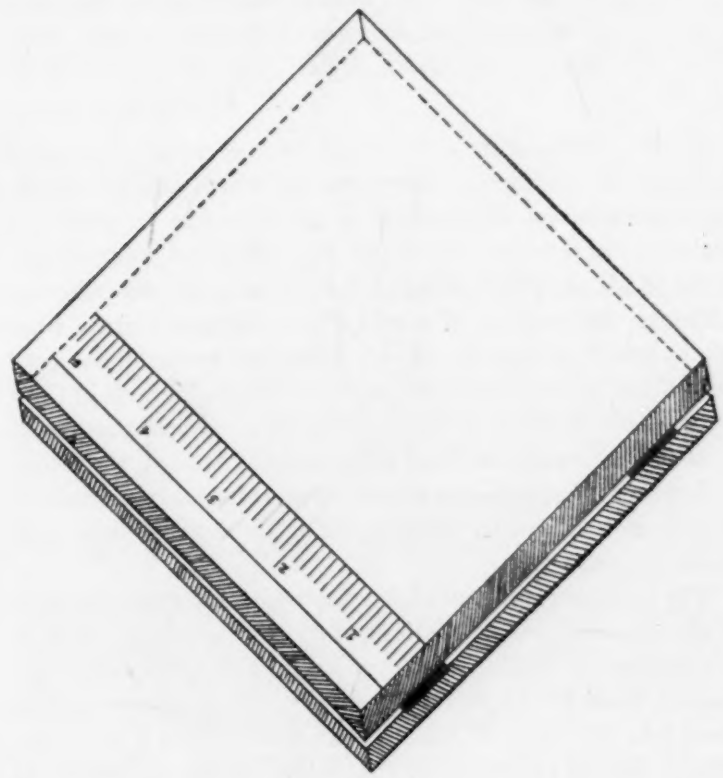

FIG. 1

consists of a piece of plate glass, $\frac{5}{8}$ inch thick, mounted on top of a small mirror. This is placed on the stage of a binocular dissecting microscope, and the object to be viewed is placed on top of the glass plate. The lower surface may be seen by merely focusing toward the object a distance equal to slightly less than twice the thickness of the glass used. This action brings the image of the lower surface distinctly into view, and the results are the same, regardless of the magnification used. In the present model a millimeter scale has been slipped between the mirror surface and the plate glass, but a scale,

scratched or etched into the glass itself, might be more useful. A strip of material of the same thickness as the scale was placed between the mirror and the glass on the side opposite the scale. This was necessary to offset the tilting effect of the scale.

Glass of a thickness less than that specified above may be used, but with thinner glass the image of the lower surface is not perfectly clear, and only small objects (1–3 mm.) may be studied. If the $\frac{5}{8}$-inch glass is used, the image of the lower surface is as clear as that of the upper. The use of the thicker glass also permits the study of objects up to about 5 mm. in size.

There is also a definite relationship between the distance of the light source from the plate glass and the image obtained. The light should be placed 3–4 inches from the plate glass and as directly over the system as the microscope permits for optimum results.

Saturation Concentrations of Triethylene Glycol Vapor at Various Relative Humidities and Temperatures

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Recent experiments carried out in this laboratory have indicated the relatively narrow margin which exists between the concentration of triethylene glycol vapor required for optimum bactericidal action and the saturation point of this vapor in air of various relative humidities and temperatures. Although the presence of a mist due to supersaturation with triethylene glycol has been shown to produce no harmful effects on animals living in such atmospheres for long periods of time (*2*), this condition is undesirable for psychological reasons in situations of human habitat. It becomes important, therefore, to determine the maximum concentration of glycol vapor which may coexist with water vapor in the air, under various atmospheric conditions.

The following communication deals with the measurements of the saturation concentrations of triethylene glycol vapor in the presence of water vapor over a range of temperature extending from 20° to 29°C. Essentially, this problem resolves itself into the study of vapor-phase equilibria in a two-component system composed of triethylene glycol and water. If each component of this mixture obeyed Raoult's law, the equilibrium concentration of the glycol vapor at a given temperature would diminish linearly with an increase in the water vapor concentration, as shown by the dotted line in Fig. 1. However, the chemical nature of the two compounds suggests that their solutions would exhibit deviations from ideal behavior. Such deviations from Raoult's law have been confirmed by the experimental measurements here presented.

A complete description of the apparatus and experimental technique will be presented in a forthcoming publication.

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The experimental procedure involved an adaptation of the principle of the condensation method recently developed for the determination of vapor pressures of pure liquids (*1*), which permits determination of the equilibrium compositions of the vapor in multicomponent mixtures. Each component of the

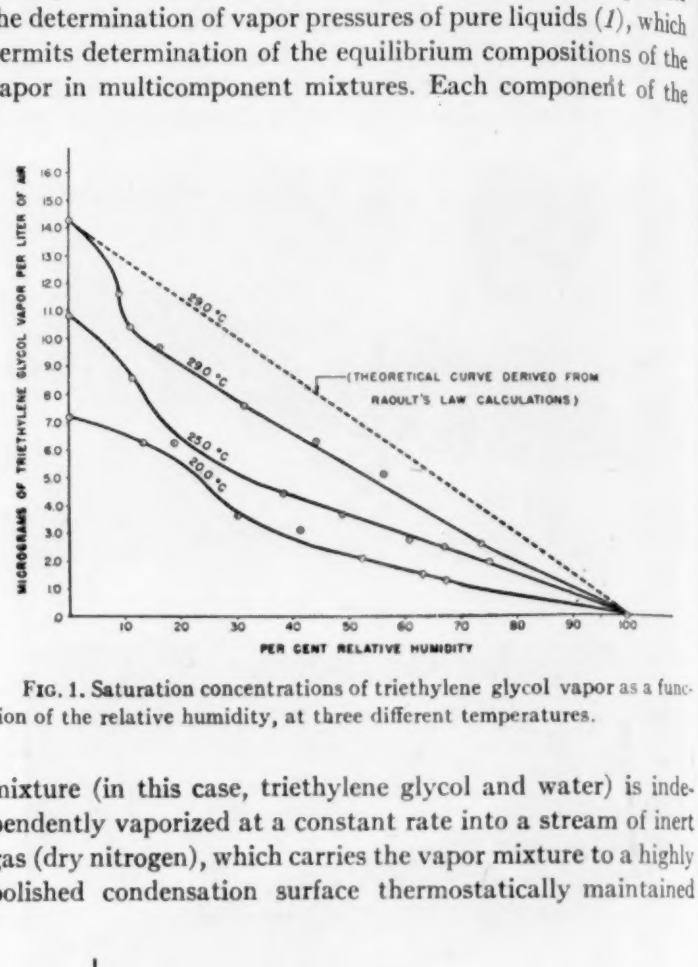
MICROGRAMS OF TRIETHYLENE GLYCOL VAPOR PER LITER OF AIR
PER CENT RELATIVE HUMIDITY
(THEORETICAL CURVE DERIVED FROM RAOULT'S LAW CALCULATIONS)
29.0 °C
29.0 °C
25.0 °C
20.0 °C

FIG. 1. Saturation concentrations of triethylene glycol vapor as a function of the relative humidity, at three different temperatures.

mixture (in this case, triethylene glycol and water) is independently vaporized at a constant rate into a stream of inert gas (dry nitrogen), which carries the vapor mixture to a highly polished condensation surface thermostatically maintained

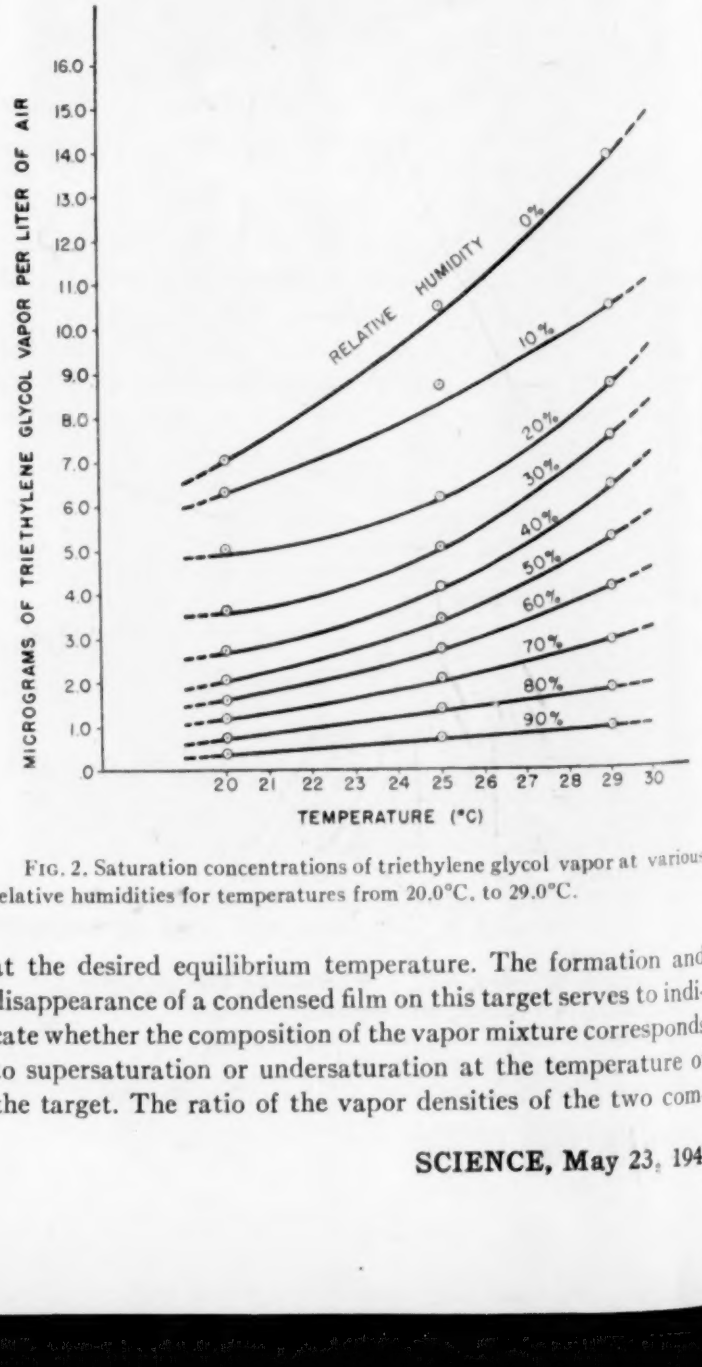

FIG. 2. Saturation concentrations of triethylene glycol vapor at various relative humidities for temperatures from 20.0°C. to 29.0°C.

at the desired equilibrium temperature. The formation and disappearance of a condensed film on this target serves to indicate whether the composition of the vapor mixture corresponds to supersaturation or undersaturation at the temperature of the target. The ratio of the vapor densities of the two com-

ponents in the gas stream is progressively varied by adjustment of the rate of flow of diluent gas until the equilibrium composition is attained. This can be done with a high degree of precision, since the equilibrium point can be approached from both sides, *i.e.* by determining the composition at which a condensate first forms on the target, as well as the point at which a film previously formed is removed by a more dilute gas mixture. This critical point, at which a condensate barely begins to form or, once deposited, barely begins to disappear, represents the equilibrium condition for the binary vapor mixture at the temperature of the condensation surface.

By means of this experimental technique the vapor-phase equilibria have been determined at three temperatures (Fig. 1). The graphical presentation of these results, with the marked deviations from a straight-line relationship, indicates that at any relative humidity the saturation point is reached with glycol vapor concentrations well below the theoretical value based on Raoult's law.[2] The area under each curve represents an isothermal region in which glycol vapor and water vapor can coexist in the air without formation of an aerosol. Conversely, any concentration above each curve identifies an atmosphere supersaturated with the vapor mixture.[3] The relative saturation of the air with glycol vapor will therefore be a function not only of relative humidity but also of temperature. A rise in temperature from 20° to 29°C. at 50 per cent relative humidity will more than double the capacity of the air to hold triethylene glycol vapor. A similar effect may be achieved at a constant temperature of 25°C., for example, by lowering the relative humidity of the air from 50 to 16.5 per cent. The accuracy of the experimental results is approximately ± 3 per cent.

By interpolation, the saturation concentrations for intermediate temperatures may be computed from the experimental results obtained at the three temperatures indicated. The temperature coefficient throughout this region is best calculated by means of the Clausius-Clapeyron equation. For pure triethylene glycol, the equation obtained is $\log_{10} P = \frac{-3{,}170}{T} + 7.758$, where P is the vapor pressure in mm. Hg and T is the absolute temperature. The partial pressure of triethylene glycol vapor at various relative humidities can be computed for intermediate temperatures by means of this equation, or a graphical interpolation may be employed. Fig. 2 presents the results of such an interpolation.

[2] It should be noted, however, that for this type of graphical presentation, positive and negative deviations from the straight line do not indicate the sign of the deviations from Raoult's law.

[3] Under natural conditions, the critical concentration at which an aerosol begins to form will also be affected by the number and type of condensation nuclei present in the air.

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Book Reviews

The operculate land mollusks of the family Annulariidae of the Island of Hispanola and the Bahaman Archipelago. Paul Bartsch. (U. S. National Museum Bull. 192.) Washington, D.C.: Government Printing Office, 1946. Pp. iv + 264. (Illustrated.) $.75.

This taxonomic treatise on the pomatiasid operculate land snails of the islands of Haiti and the Bahamas categorically divides their shells into 24 genera, and "*Incertipoma*," which is "a catch-all for all annulariids that cannot be definitely assigned to their proper genus" and which includes 11 new species. The major groups are founded mainly on the structures of the opercula, which, according to the descriptions, show remarkably little variation inside each genus. Of the 24 genera, 16 are new (and one renamed); of the 17 subgenera, 8. Of 194 species, 117 are described as new; of 96 subspecies, all but 6. In general, the dimensions of only the type shell are given, without specification of sex, although the pomatiasid males are much smaller than the females, and usually little intergradation in shell size is found on examination of the animals. Occasional notes on habitat are included. One of the most notable species is *Sallepoma mutabile* Bartsch, which is omitted from the key to the species in this new genus because its range of variation covers all the differences used for the demarcation of the other species (with the possible exception of its sutural characters, which are not described). The shells of practically every species and subspecies are illustrated by excellent photographs. The taxonomic index is apparently very complete.

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Performance records of individual trees and clones of Cinchona in Guatemala. John R. Shuman. Pp.: text, 4; Tables, 80. (Tabulation filed with Library, U. S. Department of Agriculture, 1947.)

Along with the procuring of cinchona bark in Latin-American countries during the war, great efforts have been made by public agencies, as well as by private Cinchona growers, toward the permanent re-establishment of quinine in the Western Hemisphere. The numerical results of a three-year study on the performance of individual trees and clones of Cinchona in Guatemala are made available to those interested in its commercial cultivation through this tabulation, which is being filed with the Library of the U. S. Department of Agriculture in Washington, D. C. It is the purpose of this review to bring this summary, which represents the largest tabulation of clonal performance records of Cinchona in the world, to the attention of all interested agencies, private as

well as public. The final, bound, International Business Machine tabulation is in book form.

A general idea of the scope of this work is obtained from the following summary of data represented:

Data collected and analyzed in Guatemala, C.A.: March 1943–July 1944.

Further analysis of variance of data in U.S.A.: October 1944–March 1945.

Number of chemical assays in data: 3,573.

Number of grafts attempted during 1937–42, inclusive: over 180,000.

Number of grafts set out in the field for same period: 27,531.

Number of trees one or more years in the field and included in the study: 31,058.

Number of trees measured from 1 through 7 years of age, inclusive: over 17,000.

Number of clones: 709.

Number of additional different pedigrees represented by individual trees: 1096.

Number of principal *fincas* where most of plant material is growing: 7.

Number of fields represented in above *fincas*: 27.

Range of elevations of fields: 3,000–6,000 feet, or 914–1,829 meters.

Total area in study: 35.2 acres, or 14.2 hectares.

A total of 709 clones, already established in Guatemala through grafting, together with the individual trees that were assayed but not grafted at 7 principal *fincas*, or estates, represents the material of the clonal performance records. On the basis of these it is possible for the first time to see what has been done with respect to each pedigree and clone and to make certain comparisons. The information given for each pedigree may be classified as follows: (1) identification and description by pedigree; (2) chemical analysis of bark with additional pertinent data on factors believed to affect the alkaloid content of a tree; (3) figures concerning the size of the trees, general appearance, abnormalities, and diseases; (4) ability of plants to survive in the field; and (5) data relating to the ease with which the various plants may be grafted.

Three measures of performance have been computed to permit direct comparisons between pedigrees. Differences due to age and certain environmental conditions are equalized in these three figures. The first is termed *quinine value*, a comparative figure adjusted for differences in age and differences due to fields and altitude. This is computed as a per cent of the average content of the three highest assaying types, namely *ledgeriana, ledgeriana* hybrid, and hybrid. *Size value*, the second measure, is adjusted for differences due to age and is computed as a per cent of the average of the three types mentioned above plus *succirubra* hybrid. The third figure, *survival value*, which is adjusted for age, number of years in the field, effect of original planting and replanting, is computed in terms of the average per cent survival for the same four types as were used to determine the average size of the trees.

These figures show the *quantitative amount* by which any given pedigree excels the average of all other pedigrees; *i.e.* it is a quantitative means of comparing the ability of a given pedigree to produce quinine with the average ability of all pedigrees. The figures are consequently free of all personal bias or favoritism and reflect the experience gained at 7 different estates, each directed by different individuals. On the basis of the tabulation it is now possible to select those pedigrees which are the best or the worst with respect to quinine content, size, and survival.

The reliability of the data presented is indicated by the number of individuals upon which the many figures are based. In some instances there are evidently too few observations to give any but the most preliminary indications of the true or probable performance of a given clone. Additional sampling will be necessary to determine the usefulness of certain plant material.

The results of a detailed statistical analysis of the data by the author are in the form of a manuscript entitled *Cinchona in Guatemala*. Cinchona growers in Latin America as well as in other countries would greatly benefit by its publication.

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